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THE
GEOGRAPHICAL REVIEW

VOL. XX JANUARY, 1930 NO. 1

THE HUDSON BAY RAILWAY

Harold A. Innis
University of Toronto

THE Hudson Bay route has played an important rôle at various periods in the economic history of Canada. The driving of the last spike of the railway at Churchill, Manitoba, on April 3, 1929, and the completion of the first lift of gravel on September 13 of the same year mark the end of its vacillating influence and the beginning of a period in which it will have a permanent and increasing effect on Canada's political, economic, and social future. Its geographic advantages have always guaranteed it a practical and potential place in the movement of traffic from the vast hinterland of western Canada.

The establishment of a fur-trading post on Rupert River in 1668 marked the beginning of effective competition from Hudson Bay. The difficulties of Hudson Strait were in part responsible for the relatively slow exploration and occupation of the area as contrasted with the St. Lawrence, but the establishment of posts in rapid succession at the mouths of the important rivers—the Moose, Albany, Severn, Nelson, and Churchill—during the first half century or before 1713 was evidence, on the other hand, to show that the geographic handicaps were not important once their character was understood. Moreover, the vigorous naval and military campaigns in Hudson Bay on the part of the French of the St. Lawrence against the English was an indication of the effectiveness of the Hudson Bay route as a competing route. The test came in the period after 1713 and the Treaty of Utrecht, which left the area in control of the Hudson's Bay Company when the French from the St. Lawrence were obliged to compete by penetrating the Northwest by way of Lake Superior, the Winnipeg River, and the Saskatchewan under La Vérendrye and his successors. The evidence suggests that the expansion of the French

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to the Northwest had reached a geographic limit which could not be permanently offset by French diplomacy with the Indians.

Final test of the efficiency of the route came with the revival of competition from the St. Lawrence after 1763. To French diplomacy with the Indians was added the efficiency of business organization which characterized the Northwest Company. With the birch bark

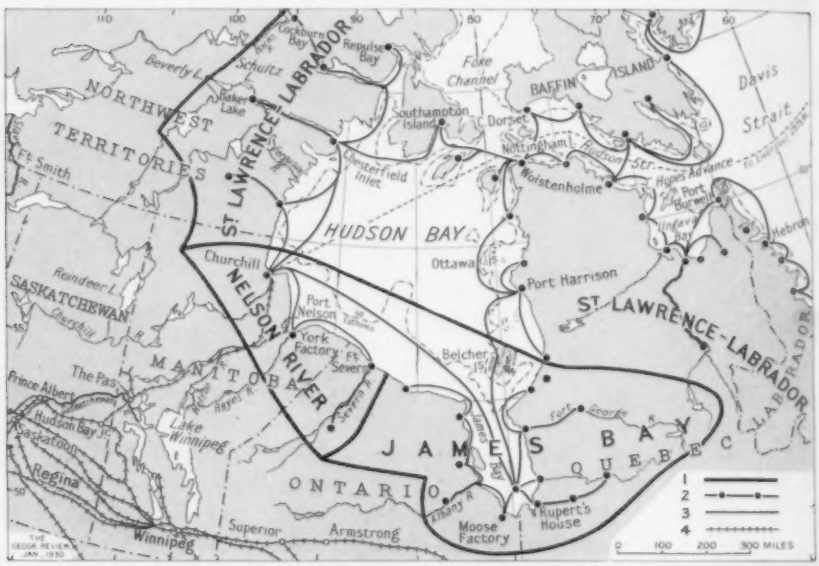


FIG. 1—Map illustrating trade routes of the Hudson Bay region. Numbers have reference: 1, 2, and 3, fur districts, posts, and routes of the Hudson's Bay Company tributary to the Bay (omitted for the remaining area); 4, railways. The 50-fathom line in the Bay is also shown. Compare Figure 2. For the relation of the Hudson Bay Railway to ocean trade routes see the map accompanying the article "The Hudson Bay Route" by John A. Cormie, *Geogr. Rev.*, Vol. 4, 1917, pp. 26–40.

canoe this company was able to expand the trade from Montreal to the Saskatchewan, Churchill, Mackenzie, Peace, and Columbia rivers. But again, the geographic advantages of Hudson Bay became evident in the amalgamation with Hudson's Bay Company in 1821 and the immediate abandonment of the St. Lawrence route. Until the opening of traffic from the south by the Red River in 1859 the Hudson Bay route was in supreme control of traffic from the Northwest. The introduction of the steamboat on the Red River and later the opening of the railroad from Montreal led to supersession of the northern route. The monopoly of the southern routes since 1874 has been the result of improved transportation and political control. The transcontinental railways have taken the place of the Northwest Company. The period after 1821 will not be duplicated in the period after 1929, as fur is a vastly different commodity from wheat, and transportation open during part of the year cannot compete with transportation all

the year round; though there is sufficient similarity in the fact that both commodities are available during the summer and that they are exported abroad against imports of manufactured products to warrant a careful analysis of the possibilities of the Hudson Bay route. How far will the geographic advantage in distance prevail with the assistance of modern transport?

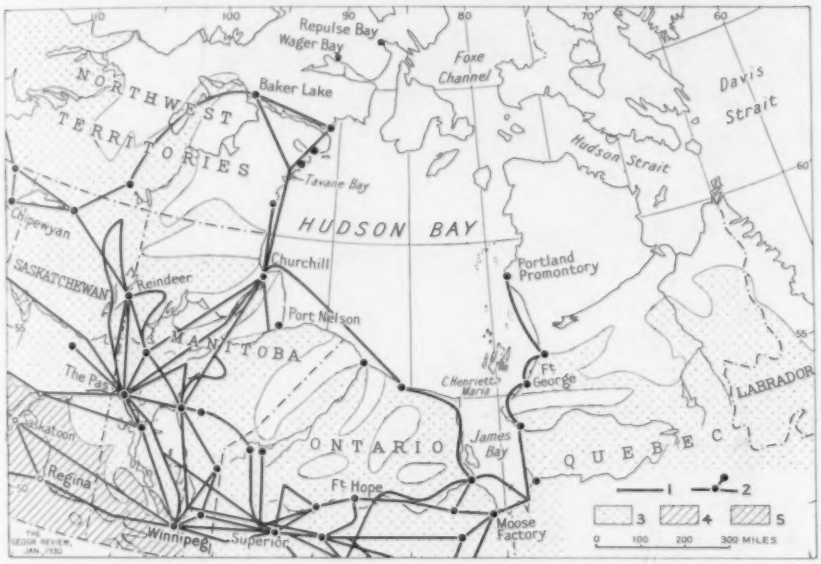


FIG. 2—Map illustrating importance of the airplane in northern Canada and the significance of The Pas as an air base. The broad character of the vegetational cover of the country is also indicated. Numbers have reference: 1, commercial air flights in 1928 from "Report on Civil Aviation for the Year 1928" (Ottawa, 1929); 2, gasoline caches; 3, forested area; 4, prairie; 5, transitional zone. Compare Figure 1. Scale of map 1:26,500,000.

INFLUENCE OF C. P. R. MONOPOLY

The railway is physically a reflection of the political and economic conditions under which it was built, as a brief survey of the several stages of its history will show. The possibilities of the Hudson Bay route with the development of steam navigation attracted the attention of explorers at an early date. They were confirmed by the long series of investigations conducted by Dr. Robert Bell in 1875 and succeeding years, as a result of which two charters—the Winnipeg and Hudson's Bay Railway and Steamship Company and the Nelson Valley Railway and Navigation Company—were granted in 1880. Thus was begun the first stage in the history of the Hudson Bay Railway.

This first stage was largely a history of the attempts of Manitoba to escape the monopoly of the Canadian Pacific Railway, whose

FIG. 3—The Pas, Manitoba, looking north. The Pas is a railway junction and important air base (compare Figure 2). (Photograph from Royal Canadian Air Force.)

charter (1881) carried a clause prohibiting the construction of railroads to the south to connect with the American lines. In a decade a large body of legislation resulted only in the building of forty miles of rail, and it was typical of the construction of the Hudson Bay Railway that this short stretch of line, which has its terminus at Gypsumville, 161 miles from Winnipeg, was destined not to be a part of the road as it was finally built.

Local Traffic and Westward Expansion of C. N. R.

With cancellation of the monopoly clause in 1888 interest in a direct route to Hudson Bay became less pronounced. At the same time lines were being built to tap the territory northwest of Winnipeg; and it became advisable for the Hudson Bay Railway interests to make arrangements with them. In consequence the Canadian Northern Railway was incorporated in 1899. The Hudson Bay road became definitely subordinated to local traffic to supply a large system which was extending its main lines and branches to the east and west of Canada. This, the second stage of the road's history, was marked by the completion of a line north from Hudson Bay Junction to The Pas on the Saskatchewan River in 1908—467 miles from Winnipeg. The line was built chiefly by private enterprise to develop traffic and, as has been alleged, to acquire a land grant. Construction was designed neither to handle through traffic from Winnipeg to Hudson Bay nor from Saskatchewan to Hudson Bay; and it leaves the present railway the heritage of an inefficient feeder system in the area from which it expects to draw most of its traffic.

During this period the Dominion government, which had sent out the Gordon expedition of the eighties, continued to conduct investigations into the navigation possibilities of Hudson Bay and Hudson Strait. In 1897 Commander William Wakeham made an extended inquiry in the strait. Other expeditions followed, all of which reported favorably on the navigation possibilities of the bay. Mounted police stations and customhouses were established, and much valuable information was acquired.

Influence of the Growing West

Settlement of the West was now proceeding with great rapidity. In 1905 the separate provinces of Alberta and Saskatchewan were created. Through these new governments the demands of the Central West became more insistent for cheaper railway rates and for the construction of the Hudson Bay Railway as a means of reducing the burdens of monopoly control in the East. Among the first steps taken to bring the plan into operation was the proposal for cancellation of the old scheme of land grants and the setting aside of

Fig. 3—The Pas, Manitoba, looking north. The Pas is a railway junction and important

FIG. 4—The Pas, a "modernized pioneer town." Founded in 1910, it now has a population estimated (1928) at 4000.

5,000,000 acres in western Canada estimated to be worth $3.00 an acre or sufficient to complete the road—500 miles at $30,000 a mile. Survey parties left Winnipeg on August 10, 1908, to locate the line. Churchill had been selected as a terminus, but the engineer's report, after a survey of both routes, recommended the choice of Port Nelson; and the route adopted by the survey to Port Nelson is the route followed by the present railroad to mile 356. The first sod was turned at The Pas on September 28, 1910. By 1913 the bridge at The Pas across the Saskatchewan was completed. In May of that year the first rail was laid, and at the end of the season eighty miles had been completed. In 1912 a new expedition was sent to Hudson Bay. In the same year the boundaries of the Province of Manitoba were extended to include both Port Nelson and Churchill, and Winnipeg and Manitoba became more definitely enthusiastic.

Construction continued during the war period; and in 1917 rails were laid to the second crossing of the Nelson at mile 332, and the grade had been completed to Port Nelson. But the financial difficulties imposed by the war were becoming grievous, and the Report of the Royal Commission in 1917 included a definitely hostile statement against further work on the line. Work was accordingly stopped; and, except for the maintenance of a fortnightly service to mile 214, all activity on the line ceased.

THE LINE COMPLETED WITH CHURCHILL AS TERMINUS

The fourth and final stage of the road began almost a decade after construction ceased in 1917. The heavy burden of the war on the finances of Canada precluded extensive railroad construction immediately after the war. On the other hand the depression of the post-war period was especially serious in western Canada and in Saskatchewan, or the Central West, and gave rise to a series of phenomena of paramount importance. High freight rates were regarded as an important cause of western depression. The possibilities of the line were kept constantly before the government's attention. The Canadian Arctic Expedition under Stefansson and its reports served to emphasize the

FIG. 5—The Pas Lumber Company, on the frontier of large-scale lumbering operations in northern Manitoba.

importance of the northern regions. In 1920 the Canadian Senate reported on the whole question of the natural resources of Hudson Bay and on the navigability of Hudson Strait. The gradual improvement of the finances of the Canadian National Railways and of the government made possible the revival of the scheme, agitation for which assumed definite form with the organization of the On-to-the-Bay Association in 1924. Estimates were passed in 1927 to provide for the reconditioning of the line, which included the replacement of native spruce ties that had decayed during the period of idleness by ties from British Columbia and the installment of new terminal facilities at miles 137 and 327.

Meanwhile the suitability of Port Nelson as a terminal had been called in question. The senate committee report of 1920, largely on the basis of evidence supplied by the Tyrrell brothers, stated "that in the opinion of this Committee sufficient care was not taken in the selection of Nelson as the terminus of the railway and that the government should not make further important expenditures upon this port without first making a new and thorough examination into the relative merits of Churchill and Nelson as a terminus for the railroad." In the latter part of 1926 the government arranged that Mr. Frederick Palmer, a distinguished English engineer, should report on the relative merits of the two ports, using as a rough measuring line the cost of providing for loading berths for three boats at one time and accommodation for six boats at one time—the boats to have a draft of not less than twenty-six feet. The length of time required to complete the port was regarded as an important factor.

The chief objection to Churchill had been the claim that the outcrops of rock which extend to the water's edge at the entrance of the harbor indicated shallow rock bottom. Accordingly, machinery was taken into Churchill under a contract with Western Canada Airways, and borings were taken in the winter of 1926–1927 in which it was shown that the harbor did not have a shallow rock bottom and that it would be possible to dredge to more than thirty feet at low water. An engineering party, after a survey in the beginning of 1927, reported favorably on the possibilities of the construction of a railroad from the

FIG. 6—Churchill Harbor, looking south from a point over Hudson Bay approximately opposite Cape Merry (compare Figure 7), September, 1929. (Photograph from Royal Canadian Air Force.)

end of the Nelson line to Churchill. With this report in hand, and after a visit in the summer of 1927, it was announced in August that Churchill would be selected as the terminus; and the work at Nelson was abandoned after the expenditure of $6,242,114. The determining considerations in making the change appear to have been the possibility of bringing boats of more than twenty-eight feet draft into the harbor immediately—against a limit of twenty-six feet at Nelson—and the estimated lower cost of the Churchill route. The works at Churchill, it was stated, could be completed in three years as against six years at Nelson. In the same year the McLean expedition was despatched with airplanes and equipment to patrol Hudson Strait during the winter season and to report on ice conditions. Meanwhile steel had been pushed ahead to mile 356 on the Nelson route.

The adoption of the recommendation of Palmer's report was followed by an energetic construction program. In 1928 it was decided to continue construction as far as the season permitted, and by October 16 steel had reached mile 428; on October 23, mile 433½; on November 1, mile 438; on November 9, mile 444½; on December 2, mile 457; on January 24, mile 475; and on April 3, mile 510, or Churchill. The last spike, wrapped in silver tobacco foil, was driven on that date. A skeleton track had been laid down over the frozen ground, and ballasting was actively pushed during the summer months with the result that the first lift was completed on September 13. After almost half a century a line of 978 miles had been built from Winnipeg to Churchill. The last section of the line from The Pas to Churchill was built chiefly as a through line to Nelson and represented a combination route, 37 miles longer[1] than the original through line between The Pas and Churchill. The difficulties it presented appear to have been the result of a lack of coördination between the engineering departments of the port and of the railroad. The choice of Nelson was determined chiefly on the advice of the railroad engineers, which the port engineers were obliged to accept; and the choice of Churchill was determined chiefly by the advice of the port engineers, which the railroad engineers were obliged to accept.

A survey of the history of construction suggests that the present location is not the most efficient for the handling of through traffic. From The Pas and Hudson Bay Junction to the south the railway system is not adapted to the effective delivery of western grain to the Hudson Bay Railway, and north of The Pas the line is not the most effective through route which might have been built. Immediate changes to improve the efficiency of the system involve the construction of a cut-off from Hudson Bay Junction to Sturgis Junction, by which Regina will have access to the route, and of a cut-off from

[1] It would be difficult to weigh the disadvantages of the original line to Churchill as measured against the cost of building, maintaining, and operating 37 miles.

Canadian Air Force.)

Aberdeen to Saskatoon giving the latter point more direct access. The Manitoba government has planned a line from Mafeking to The Pas to give Winnipeg a more direct route.

Aside from the problem of distance, the line has, on the other hand, important features which will make for the efficient handling of through traffic. The grade has been kept down to .4 northbound. The highest point, 1290 feet, occurs at mile 10, the lowest point being 10 feet at Churchill terminal: The Pas elevation is 1190 feet. Curvature has been reduced to 12.6 per cent of the mileage, and the line has few curves of more than three degrees. Construction is made up of only 51 miles in cuts; 12 miles solid rock work; and the remainder, nearly 90 per cent, in embankments. Northbound traffic can be handled at a reasonable cost from the standpoint of the physical character of the road.

Terminal Facilities and Harbor Improvements

The export of wheat, however, must depend on the terminal facilities for transshipment from the cars to the vessel hold and on the transport of the wheat from Churchill to Europe. The initial shipment of 1800 pounds of wheat on the *Ungava* leaving Churchill September 19, 1929, to be transshipped at St. Johns to the *Nascopie* and thence delivered in small sacks in England as a souvenir cannot be regarded as important to a discussion of the main problem.

In 1929 the two dredges in operation were employed on the first cut. The mud was hauled by hopper barges and by tugs and scows outside the harbor to be dumped in the bay beyond Merry Point, although rough weather made it necessary to dump a portion of the mud on the opposite side of the harbor. The harbor is not completely free from rough water, and the handling of boats in all phases of the tide and fog in the narrow entrance of the harbor is attended with difficulty. Delays, characteristic of dredging especially as carried on at great distances from a base and in acquiring experience as to the character of the bottom, limited the season's work. Additional handicaps included the working in a small area of a large number of men and the consequent effects on morale, the use of antiquated equipment brought up from Nelson, the problem of training the staff to work under new conditions in the north, the lack of coördination between the port authorities and the railway authorities, and possibly a certain amount of patronage. Dredging began on July 10 and stopped on October 20—103 working days. The first cut was completed, and a depth of 17 feet below low water over an area of 2300 by 500 feet was attained. This involved moving 500,000 cubic yards of earth. The crib work of the land side wall of the dock, 1500 feet in length by 28 feet in width, and the approach, 750 feet in length and

28 feet in width, have been completed. A part of the seat of the sea wall has been dredged to 28 feet.

Completion of the railroad will make possible a more adequate delivery of supplies and a reduction in the number and length of

FIG. 7—Churchill Harbor. Reproduction on a reduced scale of a portion of the chart of "Churchill Harbour and Vicinity (Provisional Edition)," Topographical Survey of Canada (1927). Scale of the reproduction approximately 4800 feet to an inch. The solid lines show depth in fathoms; the dotted line indicates low water.

delays, though on the other hand it may result in pressure to push unwisely the work on parts of the port to convince the public of progress. It is probable that the second cut will be more difficult to take out, as it involves working at deeper levels and on a more compact bottom. The removal of about 1,500,000 cubic yards of earth will probably require 200 days. After the removal of earth from the seat of the sea wall a deep-water crib—55 feet deep, 60 feet wide at the bottom, and 2000 feet long—must be put down. It will be difficult to complete the port in three seasons, and it is more than

probable that wheat will not be handled on a large scale until 1933, though other facilities—including a 2,000,000 bushel elevator, whose construction is reported planned for 1930—may be in readiness. Moreover, the bed of the railroad for the latter part of the line is on permanently frozen ground, and it will probably be four or five years before the ballast has settled sufficiently for the rapid hauling of fast heavy freights with wheat from The Pas.

Navigation from Port to Ocean

On the other hand, assuming that the port has been completed according to the original plan, the navigation of the harbor and strait must be considered. From the evidence available it is apparent that no general conclusions can be drawn as to ice conditions. Nevertheless, the general facts may be stated. Ordinarily the ice freezes in the harbor between November 1 and November 15, and it is possible that freeze-up might be delayed by the use of ice breakers. The opening of navigation varies considerably and may occur from the latter part of June to the middle of July or later. The most conservative opinion gives twelve weeks open navigation, but four to five months are held to be possible. The ice in the harbor and along the coast is taken out usually by combination of flood and spring tides and tends to drift south on the west side of the bay. But the position of the ice fields that have been broken from the coast depends to a large extent on the winds. The second crucial point is Hudson Strait. Icebergs come into the strait along the north side from Davis Strait but are carried out again by the current. Foxe Channel ice comes down late in the fall and, being much thicker than the bay ice, may offer serious obstruction. Field ice may be encountered at any point and may occasion the holding up of vessels. The information on navigation collected hitherto, however, is frankly inadequate: even the elaborate work done under the McLean expedition is far from conclusive. The failure of the 'Untin' Bowler expedition at Burwell was an evidence of the lack of precise information.

On the other hand if vessels are able to arrive at Churchill early in August or possibly late in July, they will be well ahead of the first shipment of that season's wheat. Wheat is harvested later in the less distant northern areas of northern Saskatchewan than in the south, but this difficulty will become less serious with the spread in use of the combine. On the other hand, steamers will not be anxious to leave with cargoes of wheat much beyond the middle of October. Within such a limit of time and, with the relatively limited accommodation of the harbor, the problem of loading becomes important.[2]

[2] The Honorable Charles Dunning estimates that in 1929, so far as the season is concerned, 100,000,000 bushels of wheat could have been moved.

difficult to complete the port in three seasons, and it is more than

FIG. 8

FIG. 9

FIG. 10

FIG. 8—Lightering timber on scows to dock at Churchill. (Photograph from Natural Resources Intelligence Service.)

FIG. 9—Churchill Harbor, looking easterly from a point over the harbor itself, September, 1929. (Photograph from Royal Canadian Air Force.)

FIG. 10—Anchoring dredge "Churchill No. 1" in Churchill Harbor, September, 1928. (Photograph from Natural Resources Intelligence Service.)

Through Traffic in Wheat

A forecast of the movement of wheat depends in part on the possibilities of a balanced cargo to the interior. This involves a study of the metropolitan growth of Prince Albert, Saskatoon, and Regina, especially from the standpoint of distribution, and a study of the changes that have led Winnipeg and Manitoba to emphasize the possibilities of the road as an instrument in the opening up of northern Manitoba rather than as an export route. Under the most favorable circumstances the Churchill route must establish itself as a competitor with the well established export routes via Montreal, New York, and Vancouver. As a Canadian National port it will probably not draw traffic from the Canadian Pacific Railway lines, and it will be made to fit into the Canadian National scheme. Sir Henry Thornton's alleged statement that the line would pay for itself even though no wheat were sent out may be interpreted as meaning that its position as an export route will not be allowed to interfere with existing Canadian National Railway arrangements for handling grain to the east. The heavy capital investment in elevators, railway tracks, and loading facilities built up over a long period for eastward wheat movement will not consent to a reduction in supply without a struggle. The Hudson Bay line may serve as a potential route, tending to reduce rates and to eliminate the heavy costs of peak load operation which are incidental to the movement of grain in the open season. Possibly its greatest value will come as a stabilizer of wheat exports and in providing western Canada and the wheat pool one more weapon by which they can free themselves of monopoly from the east and obtain greater control over their own products. It will tend to favor the agricultural districts of the northern prairie regions, to relieve any possible congestion of the eastern wheat channels, and to serve as an outlet for cattle and other farm products.

Local Traffic

In the shipment of wheat, seasonal navigation at Churchill even more than at Fort William will be responsible for a heavy peak load cost. The roadbed and equipment must be maintained all the year round to handle capacity traffic for a short season and for a one-way haul. The reduction of these peak load costs can be accomplished by increasing the traffic in the off-peak season, in particular by the stimulation of local activity.

An analysis of the possibilities of local traffic may be considered from three angles: first, immediate response to the railroad permitting all-the-year-round operation, which is the most important to its expansion; second, development extending from the bay, which is subject to prolonged closed seasons and tends to accentuate the

problems arising from the through traffic in wheat; and third, the through traffic aside from wheat originating through these lines of expansion. These phases are interrelated, but attention to each in turn will serve to provide a better perspective.

The possibilities of local traffic development are in part a result of the geographic background. The location of the through line from

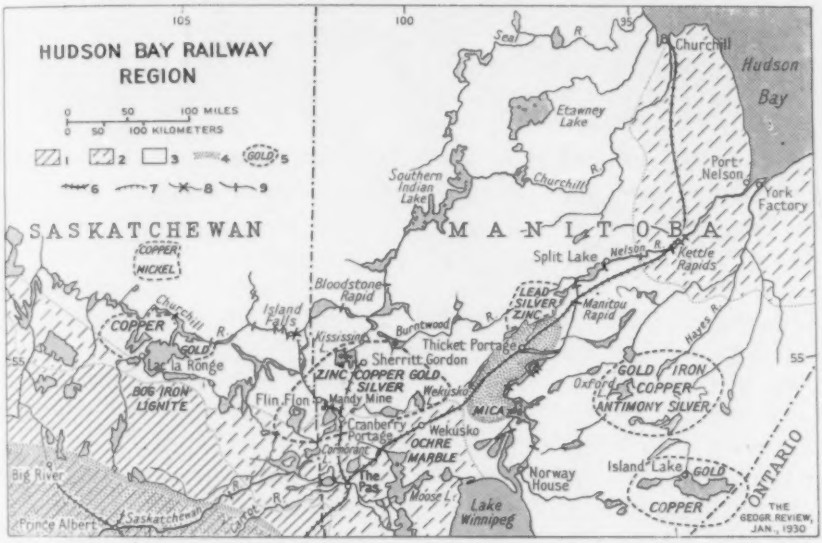


FIG. 11—The Hudson Bay Railway region and some of its resources. Numbers have reference: 1, Mesozoic strata of interior plains; 2, Paleozoic of Hudson Bay lowland; 3, pre-Cambrian of Canadian shield; 4, agricultural areas, developed or potential; 5, mining areas; 6, railways; 7, transmission lines; 8, developed water power; 9, undeveloped water power. Scale 1:9,500,000. Based on "Map showing Commercial Development in Manitoba and Part of Saskatchewan" by the Natural Resources Intelligence Service. Compare Figure 1.

The Pas to mile 356 and to Churchill was dependent on the geographic factors essential to a suitable terminus. From the geological standpoint Hudson Bay lies in the angle made by the two arms of the pre-Cambrian shield that extend to the northeast and to the northwest. Adjoining the eastern side of the western arm of the shield a relatively narrow strip of Ordovician limestone extends south from Churchill to the Nelson River and thence east. Eastward it is overlain by a belt of Silurian, which widens out to the southeast to cover a vast area reaching beyond the southerly limit of James Bay. Finally a large area of Devonian occurs in the southwestern corner of James Bay. Rivers flowing northeast from the pre-Cambrian area across the later formations are characterized by sharp breaks or rapids and at the entrance to the bay by wide shallow mouths. The whole of James Bay is less than fifty fathoms in depth (Fig. 1), and the fifty-fathom line extends far out into Hudson Bay opposite the west coast north from Cape Henrietta Maria but narrows along the coast opposite Churchill.

In James Bay ocean-going boats do not venture beyond Charlton Island, and the posts along the coast are supplied by small boats from this depot. The character of the west coast line seriously limits the possibility of port development south of Churchill. Churchill owes its position as a terminus to its location at the junction of the pre-Cambrian and Ordovician formations. The railroad north of mile 356 follows the level stretch of Ordovician that made it possible for the line to be built at comparatively low cost to Churchill. The rock-bound protected harbor and its depth are typical of the pre-Cambrian formation, whereas the easy approach of the railroad and the shallow parts of the harbor suitable to dredging are typical of the later formation. The Churchill River flows chiefly through the pre-Cambrian and, while unnavigable, it brings down comparatively little silt.

Regional Mining Possibilities

The most promising prospects from the standpoint of local traffic are those concerned with mining, as it provides an all-round in-going traffic and a tremendous stimulus to the development of other activities. The significance of the Hudson Bay line is in its position as a key to the mineral possibilities of the vast stretch of pre-Cambrian area lying north to the Arctic Ocean. The more obvious natural resources such as timber have been tapped by the Hudson Bay line as under private ownership. The lumber mill of The Pas Lumber Company represents the frontier of traffic possibilities from the standpoint of dependence on these obvious natural resources. This mill is able to draw on the timber of the Saskatchewan and its tributaries, especially the Carrot River, and has been operating since 1912. It has a capacity of 335,000 feet per day and a planing-mill capacity of 200,000 feet. In spite of the relatively short season it handled 50,000,000 feet in 1926. This is not to say that the forest industries will not be exploited north of The Pas but rather that they will be developed in conjunction with mining as a basic industry. The uncertain source of traffic provided by mining has largely prohibited railroad undertakings in Canada as private ventures in mining territory. Government ownership of railways in Canada is closely related to the geological background of the Canadian shield.

A description of the mining situation on the Hudson Bay line beyond The Pas will serve as a preface to the discussion of later possibilities. Formations other than the pre-Cambrian cannot be neglected. The marble quarry (Ordovician) at mile 42, for instance, furnishes construction material for Winnipeg buildings. But the most promising prospect comes from the minerals that have been increasingly in demand through the inventions of the later stages of the industrial revolution, copper, zinc, and lead, and from the precious

FIG. 12

FIG. 13

FIG. 14

FIG. 12—Present development at the Flin Flon mine. Tall chimney in distance, power plant for pilot mill, now used for compressor plant.

FIG. 13—Power house, now used as compressor plant, and wood yards, Flin Flon.

FIG. 14—Mandy mine, Schist Lake, Flin Flon railway.

metals, gold and silver. The demands of the war for copper led to the opening of the Mandy mine on Schist Lake, 70 miles north of The Pas. It is estimated that this mine yielded a value of over two million dollars of ore of a grade sufficiently high ($91.00 a ton) to stand the costs of transport from the mine, 40 miles by sleigh and transshipment to barge and rail to The Pas and by rail to the smelter at Trail, B. C. In 1916 diamond drilling was begun on the Flin Flon property, and at least 16,000,000 tons of ore were blocked out. On December 1, 1927, it was decided to open up the mine. A railroad 88 miles long was completed from a point on the Hudson Bay line near The Pas on September 22, 1928; and the following year a branch was carried from Cranberry Portage, 42 miles, to the Sherritt Gordon property on Kississing (or Cold) Lake.

Present plans at these mines call for a flotation mill with cyanide annex, a copper smelter, and an electrolytic zinc plant capable of handling 3000 tons of ore per day and employing when operations are in full swing, perhaps in three years, nearly 1000 men at Flin Flon, and a 1500-ton concentrating plant at Sherritt Gordon. At the same time a power plant is being installed at Island Falls on the Churchill River 56 miles northwest of Flin Flon. The falls provide a head of 55 feet; and five units are being installed, three of 14,000 horse power each, and two of 1000 horse power each, to be completed October 1, 1930. Electric power shovels will be operated on open pits, producing 2000 tons per day at Flin Flon with the energy from this site. As a result of the activities at these sites there has been a marked increase in the call for lumber from The Pas and a stimulation of the fishing industry in the neighboring lakes. It is probable that the railway will promote the export of pulpwood and encourage agriculture in the more promising local situations and trade in agricultural products from the mixed farming areas of the prairie provinces.

At Wekusko (or Herb) Lake opposite mile 83 on the Hudson Bay line, at Oxford Lake, at Island Lake, and in the Burntwood River country are other prospects waiting to be opened up. Excellent power sites are provided at Bloodstone Falls on the Churchill with 42,000 horse-power minimum flow, at Whitemud Falls on the Nelson and at Grand Rapids just above the mouth of the Saskatchewan River with 180,000 and 53,000 horse-power minimum flow respectively. Agriculture will thrive in the country surrounding Thicket Portage (mile 185). Its feasibility has already been shown in test plots established along the Hudson Bay line at Cormorant Lake (mile 42), mile 82, mile 137, and mile 185, especially in the raising of potatoes and vegetables. Wheat has been ripened and cut in 99 to 115 days at mile 185. Flin Flon will probably become the mother camp of mines in northern Manitoba. The Hudson Bay Railway built as a through line will serve as an efficient base line for feeders extending to various mines.

Supplementary Motor Transport

Looking towards further eventualities, the railroad may be regarded as a frontal attack on the northwestern arm of the pre-Cambrian shield, a base from which to explode at various points the economic dynamite that accompanies the opening of mines. The first requirement is adequate prospecting of the area. The railroad serves as a base by which the prospector can penetrate the country during the short season at his disposal. But along with the railroad he is now supplied with other modern improvements in transport, especially those involving the use of gasoline. From the end of steel at Churchill the prospector is able to transport his supplies by tractor or by motor boat to various depots along the north coast. The airplane with the use of skis and "nose warmers" can penetrate the north country before the spring break-up and place the prospector on the ground as soon as the season is open. For example, in 1929 airplanes flew from Chesterfield Inlet to Bathurst Inlet and to Fort Norman. Western Canada Airways planes at The Pas base flew 551 hours, 44,029 miles, and carried 720 passengers, 118,276 pounds of express and baggage, and 16,257 pounds of mail between December 1, 1928, and April 30, 1929.

The prospecting activities that have followed the building of the Hudson Bay Railway are an indication of its importance. In 1928 the Nipissing Corporation sent two expeditions in canoes—one from Edmonton to Slave Lake and across by Artillery Lake to Baker Lake and Chesterfield and the other from the railroad across by Split Lake and down the river to Churchill. After these surveys activities were pushed, with Term Point as a base, into the Ferguson River district and adjoining territory in 1929. The first shipment of quartz gold was brought from Term Point on the *Ungava* and sent by rail from Churchill in September, 1929. The policy of the Nipissing Corporation in selecting a small group of highly efficient men for intensive operation, making no use of airplanes, contrasts strikingly with the more ambitious and expansive programs of Dominion Explorers and the Northern Aerial Minerals Explorations Company (N. A. M. E.). Dominion Explorers began their campaign of 1929 by borrowing extensively from the knowledge of the country available, employing Mr. Blanchet at Tavane, Colonel Cornwall from Edmonton, and Captain Mack on Hudson Bay. Caches were provided from various strategic points—Tavane, Baker Lake, Wager Inlet, Bathurst Inlet, Stony Rapids, Lake Athabaska, and points on the Mackenzie. At these points, accessible to water routes, gas caches were provided from which airplanes were able to cover the adjoining country. In Hudson Bay, prospectors were despatched from Tavane as a base to various points in the interior, and from Wager Inlet and Repulse Bay.

FIG. 15

FIG. 16

FIG. 17

FIG. 15—Use of the tractor in winter, The Pas.
FIG. 16—The Pas. Western Canada Airways airplane on skids.
FIG. 17—The "Pioneer" laying steel at mile 456, Hudson Bay Railway.

FIG. 18

FIG. 19

FIG. 20

FIG. 18—Cranberry Portage, 51 miles from The Pas; now a railway junction for the Flin Flon and Sherritt-Gordon mines.

FIG. 19—Typical country north of Cranberry.

FIG. 20—Cold (Kississing) Lake, on which is situated the Sherritt-Gordon mine.

But even with facilities of modern transport the difficulties of prospecting in such country are not entirely surmounted. For instance, the *Morso*, a base ship, was lost forty miles off Churchill through fire in the engine room. In the fall of 1928 the *Patrick and Michael*, of the N. A. M. E., was wrecked at the rapids at the entrance to Baker Lake. In the summer of 1929 one of the N. A. M. E. planes was forced down for lack of gas, and two men were lost for sixteen days chiefly because of the inaccurate mapping of the Wager Inlet region. Another plane crashed on the way out from Churchill to The Pas, and a second was carried out of Churchill harbor by the tide and lost in the bay. The misadventure of the McAlpine party, forced down west of the Ellice River near Melbourne Island September 1 on an inspecting trip from Baker Lake to Bathurst Inlet, was in part due to the usual difficulties with compasses in a region near the magnetic pole. The country is relatively unknown, and many points even along the coast are more than twenty miles out on the chart. In the first assault the casualty list has been heavy in men and in money. But there are indications that a technique will gradually be worked out which will be found suitable to rapid and thorough prospecting. The airplane has certain admitted advantages, including the general ability to cover a country quickly and to pick out in a rough way the formations that appear promising; to distinguish, for example, greenstone from granite; and to enable men to get on the ground earlier and possibly to stay later. But its effectiveness depends on care in the selection of the men in the fields and on the establishment of numerous depots.

The problems incidental to an extensive scheme of operation are those that arise from lack of precise knowledge of the country, from the difficulty of arranging and adhering to any fixed schedule, from overexpansion of the organization, and from endeavor to maintain the morale of a large number of prospectors. The initiative responsible for the energetic work of the old prospector has not yet been provided by the large corporations. But, given the financial and technical organization, the experience and resources of the older mining companies, the continued capitalization of the belief in the possibilities of the Canadian shield which will provide ample public funds in support of large-scale organization, and the support of mines actually under exploitation in northern Manitoba, and it may be expected that the numerous difficult problems will be solved.

Improvements in Transportation to Mines

With the improvement of the technique of exploration and its probable successful results there follows the problem of transportation to mines that may be opened up. The methods evolved in northern

FIG. 21

FIG. 22

FIG. 21—The Hudson Bay Railway at mile 42, Cormorant Lake, Manitoba. (Photograph from Royal Canadian Air Force.)

FIG. 22—Hudson Bay Railway crossing the Nelson River at Manitou Rapids. Looking southwest. (Photograph from Royal Canadian Air Force.)

FIG. 23

FIG. 24

FIG. 25

FIG. 23—Duck boards used as snow fence at mile 396 ballast pit.

FIG. 24—Water tank and pipes along the Hudson Bay line boxed for protection.

FIG. 25—Tripod telephone pole used for frozen ground.

Ontario and northern Manitoba and in the construction of the Flin Flon railway and of the Hudson Bay Railway north of mile 356 are of basic importance to later expansion. The early exploitation of the mine during the pilot mill stage must depend on transportation other than that provided by rail. In the main the motor boat and barges in summer are combined with the caterpillar tractor in winter. Winter transport has become more important than summer transport with its dependence on portages. Tractors, for example, were engaged in hauling supplies in the winter of 1928–1929 from Flin Flon to Island Falls. On the rough roads at the beginning they hauled 35 tons in a load, but with well worn and iced roads they were able to handle a record load of 112 tons. Altogether, 2400 tons were taken in to Island Falls, making it possible to install a power plant and build a transmission line long distances from the railroad. The tractor has made accessible the territories beyond the reach of the railroad and has transformed the long closed winter into the open season of transportation.

A revolution in methods of railway construction has accompanied the improvement of the tractor. The laying of steel on the Flin Flon line began on January 3, 1928, and on March 17 Cranberry Portage was reached—51 miles in 56 working days with a record of 8700 feet for one day. This was across the relatively level Ordovician section. To this base supplies were rushed from The Pas and, with the opening of navigation, taken along the waterways of the pre-Cambrian area to various points on the line under construction to Flin Flon. The remainder of the line, 36 miles, was completed on September 22, 1928. Rapid construction across the Ordovician was accomplished by laying down the ties and track on a narrow right of way without a dump or grade and hauling in supplies over

this frozen roadbed before navigation opened. After navigation opened, ballast trains were used to dump the gravel on the track. Frozen ground became an ally to railroad construction, and winter the open season for rapid construction.

The New Construction on the Hudson Bay Line

The experience gained in the construction of the Flin Flon line was essential to the construction of the Hudson Bay line to Churchill in the winter of 1928–1929. Again the skeleton track was built on the level frozen ground of the Ordovician section. After the completion of the track, supplies were rushed at 17 to 18 miles an hour to the terminal at Churchill and to points at which ballast pits were opened along the line. Ballast trains operated from the various pits—especially at miles 396, 467, and 507—working both ways from the pits and pouring gravel on the skeleton track to build up a roadbed to hold their own weight. The tracklifting gang raised the track by jacks and filled the gravel underneath the ties. With the thawing of the ground only small gas cars could be operated over the line, much of it being under water.

The essential features of the new type of construction were the necessity for careful planning in the distribution of supplies as the various ballast pits were cut off from the base during the summer; the establishment of an efficient supervision and inspection system by which the whole could be coördinated, including the construction of a telephone line and the use of motor cars light enough to travel over the line; organization of ballast pits in which steam shovels could be operated continuously at sixteen or eighteen hours a stretch; and provision for an extensive drainage

Fig. 26

Fig. 27

Fig. 28

Fig. 26—Steam shovel working in gravel (remnant of tidal beach) at Churchill.

Fig. 27—A typical coal dock on the Hudson Bay line (mile 214).

Fig. 28—Coal unloaded at Chesterfield for the Hudson Bay post.

system. Since the grade or dump ceased to occupy an important position in the original construction of the line, drainage became much more essential. Ditches were dug over wide areas to provide a run-off for the water. The system depended not only on the existence of level country but also on the presence of large gravel ridges, such as characterized the postglacial tidal beaches[3] of the area, from which the ballast could be hauled. Other problems of construction that were solved include the driving of piles into the frozen ground for bridging and turntables with the use of steam points, the provision of an adequate water supply from the small rivers during the winter by the construction of dams, and the invention of a tripod telephone pole. The revolution in railroad construction is perhaps one of the most significant results of the Hudson Bay line. With the assistance of the tractor it will be possible to develop feeders wherever mines may be opened up inland from the road. And the method has applications in similar natural conditions elsewhere.

The technique of railroad construction in northern Canada has been revolutionized for the exploitation of mines which may be discovered in the interior. But, as in the case of exploration to the north, so in the case of mineral development the base established at Churchill by the railroad is of paramount importance. Boats wintering at Churchill can supply territory adjacent to the coasts of Hudson Bay and far into the interior by way of Chesterfield Inlet and Baker Lake, to Schultz Lake and Beverly Lake, and of Wager Inlet. The *Ungava* in the season of 1929 was the first ocean-going steamer to enter Wager Inlet and Repulse Bay, and there is no doubt but that Chesterfield Inlet is navigable. Tractors have been employed to haul goods across the neck of land from Wager Inlet to Cockburn Bay at the mouth of Backs River. The whole of the southern part of the Arctic Archipelago, which is approached from the Mackenzie River at the end of a long journey entailing numerous transshipments or from the north at great risk from the ice, can now be reached with comparative ease by Wager Inlet. The Hudson Bay route will become an effective competitor of the Mackenzie River for the development of traffic in the northern pre-Cambrian shield and the Arctic Archipelago.

The advantages of the tractor in the northern country are obvious in its ability to haul heavy loads, to be protected in case of sudden storms or blows, and in the ease with which it can be fueled and oiled in cold weather. The airplane with skis, although of proved value in Arctic winter flying, operates under various disadvantages as to landing space, storms, lifting capacity, and difficulties of fueling, oil-

[3] The discovery of a walrus skeleton in the ballast pit at mile 467 at about 8 feet depth and of a large pile of recent marine fossils (chiefly *Pecten Islandicus*, identified by Professor W. A. Parks) in the ballast pit at mile 507 supports the general argument that the land has been rising.

ing, and starting. Improvements that may be made to the tractor, and especially to the sled for travel on the northern Barren Grounds, will effectively install it as an efficient transport weapon in the attack on the Canadian Arctic. The limitations of the tractor for coast traffic should, however, be noted. Its weight is a handicap in crossing the mouths of small streams along the coast, and it has not been found altogether satisfactory in traveling over rough ice such as characterizes the tidal coast of Hudson Bay. The tractor in winter operations on the coast will probably not prove a competitor with the boats in summer.

Other Adaptations to Occupations of the North

Not only has the technique of transport been adapted to the conditions of northern Canada but the demands on the engineers responsible for the building of the Churchill town site will call for radical changes in the ordinary methods. The town site has been placed entirely under the control of the provincial government, and plans have been worked out for a population of about 2000. The frozen ground will necessitate elaborate preparations for the installation of water works and a sewage system. Fresh water brought in pipes for a distance of eight miles from the Churchill will require extensive insulation or the installment of steam pipes. Domestic architecture will also be influenced by the demands of a long cold winter. The experience of the Hudson's Bay Company in building posts and the experiments being carried out by the Canadian National Railways will probably favor the small one-story building with ample protection through the use of insulating material such as the various grades of paper board.

Modes of living must be closely adapted to northern demands. Prospectors and miners have been quick to adopt the methods of the Eskimo and to rely on his aid in living in the climate of the northern Arctic. A recent illustration is seen in assistance rendered by the Eskimos to the McAlpine expedition lost to civilization for 51 days. Boats must rely on Eskimo pilots along the difficult north coast.

Wild Life As a Permanent Asset

Other possibilities of traffic development are limited to products of animal extraction. The fur trade will be subject to decline rather than increase as a result of the competition which will follow improved transportation. The problem becomes urgent as to the methods by which wild life can be conserved and retained as an important natural resource. The Hudson's Bay Company have established a large white fox farm at Chesterfield. The outcome will depend largely on the success with which the experience of Prince Edward Island can

be transplanted to the new conditions of the Arctic. The tragedy of destroying the rich animal life of the coast through the rapid introduction of modern high-power weapons can only be averted by immediate and decisive steps. There is grave danger that the walrus, seal, and white whale will, like the right whale, be brought to the verge of extinction.

A final alternative has been suggested in the establishment of a reindeer industry. The Porsild brothers have reported to the government on the character of the moss along the west coast of Hudson Bay, and herds of reindeer are being brought from Alaska to the Mackenzie delta for ultimate distribution farther afield in Arctic Canada. The failure of the reindeer experiment conducted by the Hudson's Bay Company on Baffin Island is not a happy omen. But, on the other hand, the government may be able to train the Eskimo to handle reindeer as has been the case in Alaska. Yet all this is in the future. In any case the economic possibilities of the area from this standpoint of animal life must depend on the Eskimo. The native alone has satisfactorily solved the problems of life under Arctic conditions, and Canada must rely on him for the successful exploitation of Arctic resources. The fishing industry will be limited largely to the Arctic salmon and will gain its chief prominence as an important supply of food for local development. Fresh fish will undoubtedly be exported from the bay to the Prairie Provinces, but the industry has been by no means as yet thoroughly investigated as to its possibilities. Arctic salmon are found in large numbers along the coast, especially at Eskimo Point, and whitefish are caught in large numbers in Churchill Harbor.

A discussion of local traffic possibilities may conclude with the tourist. Fort Prince of Wales and Sloop Cove are impressive historic monuments. With reasonable precautions the game of the country north of Churchill—especially the caribou—may become an important attraction. Certainly the natural beauty of Wager Inlet has an attraction of its own. But the tourist business can be regarded only as supplemental to the main development.

Conclusion

The success of the Hudson Bay Railway must depend largely on local traffic. Mining is of the most immediate importance, and numerous other industries will be built up around it. The railroad presents a pressing challenge to all the scientific skill the Canadian people can command.

Through traffic depends in turn on local traffic. The importation of goods essential to the mining industry of the area may be encouraged by the possibility of exporting wheat as ballast. The three months

available for navigation through the straits must be utilized to the greatest advantage in importing goods to meet the demands of western Canada and the opening up of the Hudson Bay region. Chances of success would be materially reduced by concentration on the export of wheat. Extensive warehouse facilities for goods coming into Churchill and loading facilities should be equally important with grain elevators. The weakness of the present situation is the lack of an organization to exploit the opportunities of the new port. The Hudson's Bay Company alone has taken immediate advantage of the new port in making it the center of its distributive system as opposed to Montreal. If the port is to flourish and the railroad to succeed, organization is essential. Wheat can be used as a magnet by which imports can be brought through Hudson Bay.

Through traffic in wheat involves heavy overhead costs which can be reduced by the carriage of other commodities in the off-peak season. Progress in mining on the east and west coasts of the bay together with the evolution of technique in prospecting and transportation along the railway will contribute largely to this end. Mining and hydro-electric development are important to the growth of subordinate industries—agriculture, fishing, and lumbering—both for meeting local demands as well as for exportation. Mining in northern Manitoba, northern Saskatchewan, and possibly northern Alberta, as well as in the Northwest Territories will be furthered by the cheap transport afforded through Hudson Bay.

It would be dangerous to predict the course of events that will follow the construction of the road, but certain tendencies may be suggested. The accumulation of information on the climate and geography of the strait and bay, the establishment of broadcasting radio stations, the improvement of available harbors along the strait and the north Labrador coast, modern devices for improving transport, including the evolution of a type of boat with reinforced bows and beams suitable for bulk cargo, will probably lengthen the period of navigation beyond the twelve weeks generally conceded. Navigation may well be accomplished through the assistance of Newfoundland seamen who have been bred and trained to the handling of ice conditions. The Maritime Provinces of Canada should be brought more closely in touch with the rest of the country provided they can seize the opportunities afforded by the western market. And not only the Maritimes but England will compete here with eastern Canada. The shipment of six bales of goods through Churchill by the Hudson's Bay Company in 1929 is a precedent that will be rapidly followed up. The opening up of mines in the northern sections of the Prairie Provinces will make for a better-balanced agriculture, providing a market for other farm products than wheat.

All these are possibilities. Their realization depends on the ability

with which the people of the Prairie Provinces can adapt their social, economic, and political organization, which has been built up in relation to railroads and w heat, to boats and minerals. In the Hudson Bay Railway Canadian ngineers have made a most conspicuous success. It remains to b seen whether the front line which has been pushed forward in the firs attack on the last vast stretch of the Canadian shield will be occupi and consolidated; but it seems reasonable to suppose that Canada ll continue to take advantage of the later stages of the industrial r olution based on gasoline and to broaden out toward the north. he political framework of the Dominion worked out under the fur rade will be gradually filled in economically.

THE CERRO DUIDA REGIOI OF VENEZUELA

G. H. H. Tate and C. B. Hitchcock

American Museum of Natu[illegible] History

FIG. 1—Cerro Duida, sketched from Esmeralda. Marahuaca in distance to north.

IT remains for me to speak of the most solitary and remote Christian settlement on the Upper Oroonoko. Opposite the point where the bifurcation takes place, the granitic group of Duida rises in an amphitheatre on the right bank of the river. This mountain, which the missionaries call a volcano, is nearly 8000 feet high. Perpendicular on the south and the west, it has an aspect of solemn greatness; it's summit is bare and stony, but, whenever it's less steep declivities are covered with mould, vast forests appear suspended on it's flanks. At the foot of Duida is placed the mission of Esmeralda, a little hamlet with eighty inhabitants, surrounded by a lovely plain, bathed by rills of black, but limpid waters. This is a real meadow, decorated with clumps of the mauritia palm, which is the sago-tree of America. Nearer the mountain, the distance of which from the Cross of the mission I found to be 7300 toises, the marshy plain changes to a savannah, and spends itself along the lower region of the Cordillera.[1]

Cerro Duida is the dominant feature in the mountainous country lying at the western end of the Parima Mountains in the west of Venezuelan Guiana. It is an elevated sandstone plateau, roughly four-square, with sides some ten to fifteen miles in length. All travelers on the upper Orinoco have commented on the striking appearance of Duida. Humboldt, though not the first explorer of the region,[2] was the first to give a vivid account of the mountain. That it is a sandstone and not a granite mass was pointed out by Robert Schomburgk, whose observations (1838–1839) on the region between the Parima Mountains and the Duida group are still the best available.[3] Others have visited the region at various times and reported on it; neverthe-

[1] Alexander de Humboldt: Personal Narrative of Travels to the Equinoctial Regions of the New Continent, during the years 1799–1804, transl. by Helen Maria Williams (8 vols., London, 1818–1829), Vol. 5, Part II, pp. 502–503.

[2] On the work of José Solano, the Spanish Boundary Commissioner, Apolinar Diaz de la Fuente, and Alferez Bobadilla in the mid-eighteenth century see F. Michelena y Rojas: Exploración oficial por la primera vez desde el norte de la America del Sur . . . de 1855 hasta 1859, Brussels, 1867.

[3] R. H. Schomburgk: Reisen in Guiana und am Orinoko, Leipzig, 1841. *Idem:* Journey from Fort San Joaquim, on the Rio Branco, to Roraima, and thence by the Rivers Parima and Merewari to Esmeralda, on the Orinoco, in 1838–9, *Journ. Royal Geogr. Soc.*, Vol. 10, 1841, pp. 191–247.

less the upper Orinoco basin remains largely unexplored. Duida was reported impregnable. In 1928, however, the summit of Duida was reached by the Tyler Duida Expedition,[4] and three months were spent on the top of the mountain. The object of the expedition was a general biological and physiographical survey of the Duida region.

The party left Manáos, Brazil, on the river steamer *Inca* for Santa Izabel, 425 miles up the Rio Negro, and there chartered a large launch with two *batelões* (cargo boats) 30 feet in length lashed one on either side. On these the party completed the trip—up the Negro by way of the Casiquiare Canal, that curious natural connecting channel, to the Orinoco, and about 18 miles up that river to Esmeralda, the last Venezuelan settlement. Esmeralda is only eight miles from the escarpment of Duida.

Rio Negro

The Rio Negro may be divided into three distinct sections: the lower, middle, and upper river. The lower river, varying from five to ten miles in width, with a difference of some forty feet between high and low water, studded with islands, bordered by gloomy deserted forests, invaded for many months of each year by the flood waters, is the portion most often described. This section may be considered as reaching about 400 miles from its mouth. A gradual transition leads from the lower river to the middle section which is one long succession of rapids flowing over granites and gneisses. Apparently these are the roots of a series of scattered hills that cross the Negro. The length of this section, of which the upper half has most of the rapids, is about eighty miles. It ends at the mouth of the Uaupés River. The upper Negro is practically without rapids, has a moderate current, and runs to a large extent between high, vertical banks.

In the old rubber days Moura, Barcellos, and other towns were important trading points, but during recent years the population along the river has been steadily declining. Its principal products are Brazil nuts, some balata, rubber, and piassaba—the fiber of a palm (*Leopoldinia piassaba*) used for making cables, brooms, and doormats. Brazil nuts and piassaba are exported in considerable quantities. At the beginning of the present year the price of balata advanced slightly, but the rubber trade continues to decline. The *Inca* leaves Manáos for Santa Izabel on the third day of each month to carry up provisions and bring back products of the river. During the crop season much greater quantities of fiber than the steamer can accommodate are assembled in the thatched warehouses along the banks. Under these conditions the cargo space is prorated among

[4] The Tyler Duida Expedition was organized by the American Museum of Natural History. Its personnel consisted of Mr. Sidney F. Tyler, Jr., through whose financial support the expedition was made possible, Mr. R. S. Deck, ornithologist, and the writers.

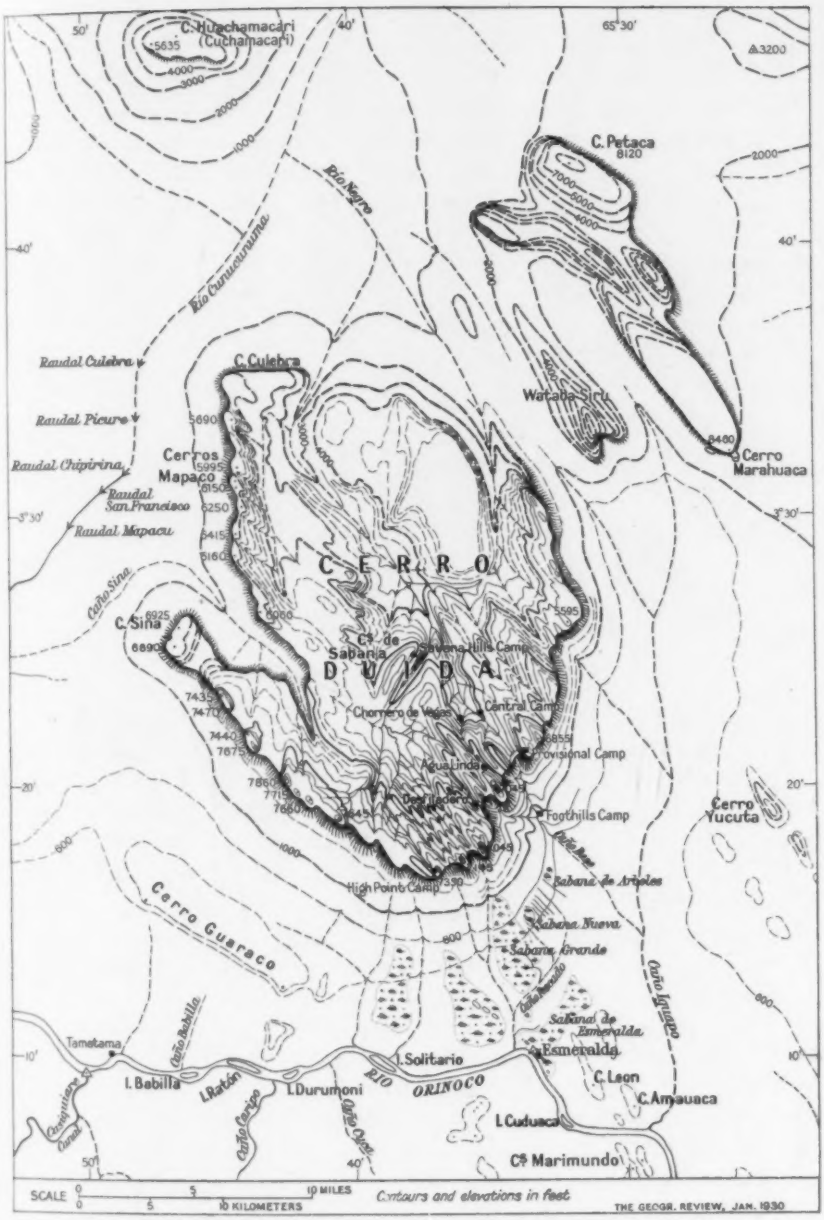


FIG. 2—Map of Cerro Duida, scale 1:500,000. For construction see Appendix.

the various shippers, and only a portion of their crop is accepted. Brazil nuts are measured by hectoliters and loaded in bulk in great bins on the steamer. At Manáos the entire cargo is carefully re-measured, and any difference discovered in the total volume of nuts

is apportioned among the shippers. Turtle fishermen also carry on a certain amount of business.

From an economic standpoint the middle and upper parts of the river can be treated together. The population is mainly collected about the Salesian Mission at São Gabriel, some twenty miles below the mouth of the Uaupés, at the Brazilian frontier station of Cucuhy, and at the Venezuelan frontier station of San Carlos. The mission

FIG. 3—Cerro Duida, from the Orinoco below Esmeralda.

maintains a school for general education of the Indian children of the region and a well equipped hospital started by Dr. and Mrs. A. Hamilton Rice. A government wireless station has been erected at São Gabriel. Elsewhere on the river there are only scattered houses whose owners eke out a subsistence by gathering balata and rubber. A few miles below the mouth of the Casiquiare is the frontier between Brazil and Venezuela, with Cucuhy and El Carmen, the military and customs posts for their respective countries.

CASIQUIARE CANAL

The Casiquiare Canal has been very thoroughly reported upon by Dr. Rice.[5] The canal seems to have had only two periods of relative prosperity—the first when the Spaniards in the eighteenth century established a set of military posts in the region, and the other in the first decade of this century when the price of rubber reached its high level. At other times the river has remained practically without population, a scattering of huts separated by many hours of travel being the only indication of human residence. In 1928–1929 very few dwellings were noted: at Solano, a few people; at Buena Vista, seven huts and a shed all deserted; near Caño Durutumoni, three

[5] A. Hamilton Rice: The Rio Negro, the Casiquiare Canal, and the Upper Orinoco, September 1919–April 1920, *Geogr. Journ.*, Vol. 58, 1921, pp. 321–344.

empty huts in fairly good condition and a number of scarred rubber trees; Quemapure, absolutely deserted and the huts in ruins; Piedra Pintada, a hut with but one man, a woman, and a child; Pato, absolutely abandoned; Capyvara, the only flourishing settlement on the whole river; Buenos Ayres, in existence in 1919, so overgrown that nobody, not even the pilot, knew when we passed it; a few other huts. At the present time a small amount of rubber is being worked.

FIG. 4—The southern portion of Duida from Sabana Grande.

Except at the time of lowest water, January to March, the Casiquiare is navigable in any good-sized launch, there being only one rather bad rapid, the Raudal San Sebastian. Even at nearly low water early in March the launch managed to pass through to Esmeralda, when it encountered its chief difficulties at the Raudal Jacamin.[6] On the Orinoco above the junction of the rivers there are only two settlements of any importance, Tamatama and Esmeralda. Tamatama is reached by the launch in half an hour, and Esmeralda about six hours later. A rather unimpressive first view of Duida with its cloud capping is afforded from a distance of some forty miles.

The alternative way of arriving at Esmeralda via the Orinoco is by river steamer *Delta* from Trinidad to Ciudad Bolivar, then by a regular monthly launch service to Puerto Ayacucho just below the Atures Rapids. At the end of November, 1928, the capital of the state of Amazonas was shifted from San Fernando de Atabapo to Puerto Ayacucho. Above this place the construction of a 65-kilometer cart road has been recently undertaken, and in 1928 it was passable,[7] though not quite completed, to San Ariapo above the

[6] A rapid, taken as a whole, does not necessarily become progressively more dangerous as the water level falls, since, while certain channels are reaching the dangerous condition, other previously unusable passages become comparatively calm.

[7] Dr. H. S. Dickey, whose attempt during the spring of 1929 to reach the sources of the Orinoco failed because of the revolutionary state of this section of Venezuela, reports the road entirely overgrown and several bridges unfinished.

Maipures Rapids. Beyond this port one small government launch, the *Mariposa*, is able to go through to Esmeralda except in the height of the dry season. If it is out of commission, large thatched canoes can be obtained to complete the trip in fifteen to twenty days.

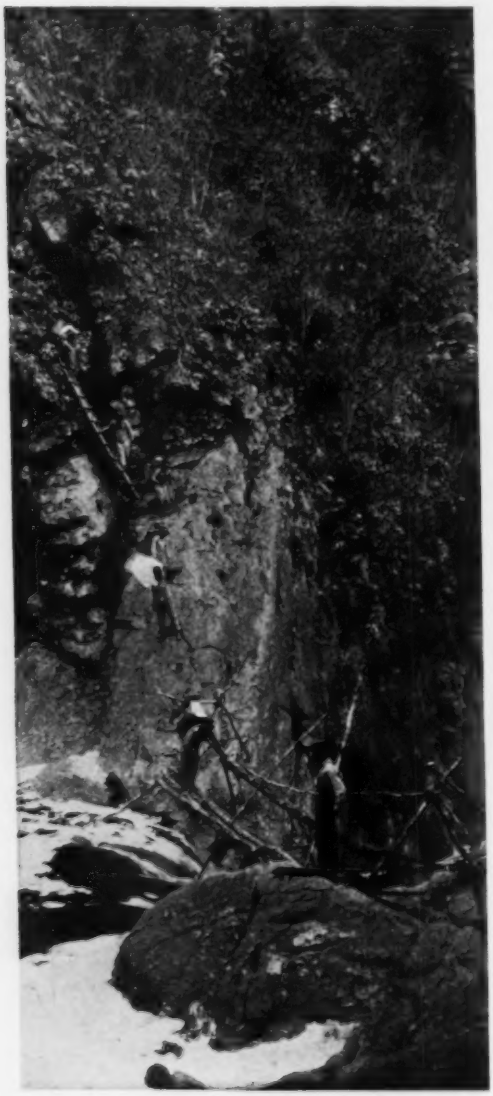


FIG. 5—Bridge across the falls at Caño Negro. Note the type of ladder used on the trail.

ESMERALDA LOWLANDS

Esmeralda now consists of nothing but a single native hacienda, housing a score of people whose principal occupation is gathering balata and caring for about fifty head of cattle—the cattle being so far away from market that they cannot be sold but serve merely to provide food for the owner.

The house stands about a hundred yards from the north bank of the Orinoco in a broad, open savana and is somewhat protected from the prevalent northeast winds by a low ridge of shattered sandstone. The savana is clothed with moderately tall grass and extends to the west for half a mile, to the northwest for nearly a mile, and to the northeast beyond the ridge for four miles. Its river frontage is about half a mile.

From the edge of the Orinoco Cerro Duida is seen ten miles away behind the Esmeralda Ridge. Even in the dry season it is usually partly hidden by mist and clouds, but frequently in the early mornings and late afternoons the precipitous scarps stand out sharply. Beyond it to the northeast the slightly higher Marahuaca can be seen.

The Esmeralda savana is mostly flat, but there are several low portions, either swampy all year or subject to inundation by the Orinoco for several months during high water. It is traversed from east-southeast to west-northwest by the low sandstone ridge already mentioned. The ridge, whose steepest side faces south, is formed of quartzite with some interbedded conglomerate composed of quartzite pebbles and slaty fragments. It is cut by many veins of quartz. The rocks are folded and highly fragmented, with large loose blocks piled indiscriminately together on the slopes. Away from the ridge the savana apparently overlies sandstone; but along the banks of the Orinoco, within 800 feet of the house, are outcroppings of granite; and the land to the south, seen later from the summit of the mountain, has low rounded hills that suggest an igneous rather than a sedimentary country rock.

The soil of the savana is generally firmly compacted, its composition being mainly sand and a little argillaceous matter, except at the river bank, where it is mixed with flood-water deposits. The normally swampy portions contain quantities of assembled humus.

Vegetation has been considerably impoverished by the grazing cattle and by the custom of burning over the savana each dry season. The flat, dry portions are clothed with pasture composed of several grasses intermixed with sundry low herbs. Moriche palms are the dominant plant in the swampy portions. The area inundated by the Orinoco is forested and almost without undergrowth, though during the dry season great festoons of razor grass spring up and smother everything. The ridge is low, no streams originate on it, and its vegetation is all strongly drought-resisting. Cornucopia-shaped termite nests two to three feet in height and a foot in diameter at the base are scattered over considerable areas of the drier parts of the savana.

Birds are quite numerous—several species of nighthawks, grass finches, swallows, and tyrants. The *morichales* afford congenial homes for moriche orioles, the wood hewer *Berlepschia*, palm swallows, and palm tanagers. Meadow mice, *Zygodontomys*, and, rarely, giant anteaters are practically the only mammals found in the Esmeralda grasslands. The apparent absence from Esmeralda of certain characteristic savana forms—meadow larks, mocking birds, *Colonia*, foxes, cotton rats, rattlesnakes, Tegu lizards, and such low trees as *Curatella americana*, *Vitex schomburgkiana*, and *Casearia fockeana*, common on the savanas of the Rio Branco region, should be noted.

A summary of the climatic conditions experienced during the stay of the expedition at Esmeralda will also apply to the rest of the area at a moderate distance from the precipices of Duida. In October the normal weather was as follows: nights clear, mornings clear and sunny, late afternoons frequently marked by violent thunder and

wind storms accompanied by heavy rains coming invariably from the northeast. The shade temperatures averaged: 6 a.m., 81°; 2 p.m., 91°; 7 p.m., 86°. The afternoon storms grew less frequent as the dry season came on, but with the winter solstice a period of heavy rains, accompanied by only slight winds, interrupted the dry period and lasted into January. The natives had predicted this rainy period and said that it occurs with greater or less intensity each year; they even have a name for it, *los Nortes*. With the passing of the *Nortes* the real dry season set in. Brooks dried up, grasses shriveled, and forest trees of certain kinds shed their leaves, while nearly all plants had passed their flowering periods and were shedding seeds. The new rainy season was heralded in the beginning of March by gathering clouds in the northeast; showers became usual toward evening, frequently accompanied by violent thunder and lightning. With the rains the jungle awoke from its period of aestivation, vegetation began to grow rapidly, and hordes of flying creatures were attracted nightly to the light in camp.

Lowlands Near Base of Mountain

As one proceeds directly toward the nearest part of Duida from Esmeralda, a broad strip of forest enclosing one small savana is passed. Beyond this is another large savana, which we named Sabana Grande.

The ground in the belt of woods is so level that very little definite run-off has been established, and it is seamed by a network of tiny insequent channels which lead into one another but in which little or no current is appreciable. The forest may be considered typical of the low country about Duida. A conglomerate composed of sandstone pebbles identical with the rock of the mountain is exposed in the stream (called by us Caño Pescado) just southeast of Sabana Grande. The trees are tall and straight with the ceiling about a hundred feet above the ground. A number of fine, large species of palms are widely distributed through it.

Birds are plentiful; mammals generally scarce, although all the well known jungle forms are to be encountered there—deer, tapir, peccary, anteater, jaguar, puma. Monkeys only were fairly common. Spider monkeys and Cebus monkeys, together with turkey-like curassows and guans, formed an important item in feeding our men and supplying the settlement at Esmeralda.

The southeastern portion of Sabana Grande is a sandy swamp; the remainder rises gradually up the talus slope of the mountain, the greater part representing an outwash fan. The ground throughout is very sandy, the part nearer the mountain being clothed principally with grasses. The more fertile portion with its many species of flower-

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 6—Savana Hills, looking toward the north.
FIG. 7—Looking to the southwest from Savana Hills. Caño Negro flowing to northeast.
FIG. 8—The southeastern scarp seen from Savana Hills.
FIG. 9—Marahuaca and associated mountains to north of Mt. Duida from Savana Hills.

FIG. 10—Savana Hills vegetation (4800 feet).

FIG. 11—In the more humid parts of the summit.

FIG. 12—Comparatively dry woods of summit.

ing herbs and bushes presents a marked contrast with the grazed-over Esmeralda savana.

The country to the northeast of Sabana Grande is principally forest. The land is well drained and contains few distinctive features. The main river originating from the southeastern scarp flows, after it emerges from the foothills, approximately south 35° east and apparently is a tributary of the Iguapo. The bed of Caño Base, as we named it, is full of large, rather flat stones, which arrange themselves like so many shingles pointing downstream so as to offer the minimum resistance to the water. Most of the land is forested, in places largely with palms, one kind of which, the *seje*, bears a fruit from which can be made a very nourishing drink. Fire has passed through considerable portions of the forests here, leaving nearly impenetrable tangles of fallen logs overgrown by Heliconias and vines. A section of outwash, stony and rough, was named Sabana de Arboles from the fact that it was covered with coarse grass interspersed with small, arid-country trees, which gave it an orchard-like appearance.

Foothills and Scarps

The eastern scarp, which cuts across a series of folded, faulted sandstone beds, presents a series of eight or ten great headlands with very steep V-shaped valleys between them closed in at their heads by precipices. The headlands are etched out by erosion until in some cases high knife-edges only a few meters in width result. At the ends of the promontories, where the two eroding forces meet, there are produced exceedingly steep, true knife-edges, inclined at an angle of perhaps 60° and terminated in outward-facing, triangular facets. The line joining the bases of the facets is slightly curved. The headlands decrease gradually in altitude from south to north.

The southwestern escarpment, nearly parelleling the strike of the rocks, is some twenty miles in length, terminating at its western end in the partly separated double peak Sina. Its altitude except at the Sina gap was found to be between 6700 and 7800 feet. Instead of a series of marked salients and reëntrants, the side presents a number of narrow, nearly horizontal bands of precipice, some as much as a hundred feet in height and a mile in horizontal extent with intervening steep slopes of detrital material. One belt of precipice, very noticeable from the Orinoco, dips slightly downward from west to east. The talus slope at the base of the southwestern escarpment reaches out for some two to four and a half miles; that at the base of the southeastern escarpment for only about a mile to a mile and a half. The upper limit of the talus is between 2000 and 2800 feet.

From the lowland forests our trail leads up forested talus to the foot of one of the headlands, for the ascent of which more than a

hundred ladders were constructed of poles lashed with vines. Nearly three tons of cargo had to be carried to the summit, and the trail as first cut was barely passable for men without any load whatever.

FIG. 13

FIG. 14

FIG. 13—Indians descending one of the ladders on trail to summit.
FIG. 14—The giant bromeliad, 4000-foot zone marker and source of water where no streams existed.

Vegetation on the promontories is quite sharply differentiated into two types. The lower parts and the sides leading up to the knife-edge are covered with forest; the crests of the ridges from 4000 feet up to the highest part are clothed with wiry plants of similar species to those growing on the summit. The low limit of the giant *Bromelia* emphasizes the intergrading of the two zones. One or two moist, sheltered pockets exist well up towards the top, and these contain tangled forest growth similar to that of the summit valleys.

Animal forms on the Duida slope, like the vegetation, show strong differentiation. The descending crests of the ridges clothed with a mountain-top flora bring down with them numerous species of birds and animals otherwise restricted to the highlands. On the other hand,

the intensely humid forested sides of valleys bear many species of strictly endemic plants and animals found neither on the exposed plateau nor in the tropics below 2000 feet.

FIG. 15

FIG. 16

FIG. 15—Central camp on top of the mountain. Note typical arboreal summit vegetation.
FIG. 16—Cliff face on southwest scarp, showing intense folding and valley tendency to conform with synclines.

SUMMIT OF DUIDA

From the top of the ridge by which the ascent is made the tableland is seen to be not horizontal but depressed in the center, with slopes leading inward from all sides. To the north, where the border of the mountain becomes lower, the principal drainage appears to find its outlets.

Although the entire mass is but one mountain, the western peaks, visible also from the Cunucunuma River,[8] have received different

[8] Michelena y Rójas, *op. cit.*
J. Chaffanjon: L'Orénoque et le Caura, Paris, 1889.
Leo E. Miller: The Land of the Maquiritares, *Geogr. Rev.*, Vol. 3, 1917, pp. 356–374.

Indian names. The partly isolated southwestern tip is called Cerro Sina; the northwestern side, Cerro Mapacu; the continuation of the northern end of Mapacu to the east, Cerro Culebra.

The promontories of the eastern scarp are seen to be continued into the interior of the table-land as plunging, parallel ridges controlled by the intensely folded structure of the mountain. Their general strike is north 35° west. The distant northwest side has similar

FIG. 17—Southwestern scarp of mountain taken at 7 a. m. on a very clear day. Looking northwest.

features sloping towards the middle. In the central portion a low range of hills running east-northeast terminates the ridges of the eastern side. The rock is mainly pinkish, cross-bedded quartzite with some interbedded layers of red slate (12–16 feet wide). The slate, as well as the transition beds of sandstone, shows numerous ripple marks. The quartzite, however, when not close to the slate gives evidence of but few ripples. The sandstone underlying the shale is somewhat lighter colored than the overlying beds. A few small concretions, possibly organic in origin, were found at one slate outcrop. Other than these no fossils were discovered.

The rocks are intensely folded, with the more steeply inclined limbs to the southwest, and at times pass into overthrusts. Where these appear on the cliff faces, vegetation has grown in the brecciated portions and marks the fault planes clearly. The region evidently underwent a considerable period of erosion before the present uplift, for the complex folds are to a large extent planed off.

The southeastern scarp bounds a stream system controlled by topography and structure draining to the northwest as far as a central transverse ridge named by us Savana Hills because of its savana-like appearance due to its cover of low-growing bromeliads, sedges, and grasses. Here the water is diverted to the east-northeast and has

carved a narrow gorge for itself. Subsequently it turns due northwest through a rather broad valley and is believed to empty into the Caño Negro, affluent of the Cunucunuma River. Water from the interior of the southwestern scarp in part empties through the Caño Negro, in part through a gulf between Cerro Sina and the main mass.

Except at Savana Hills the portion of the surface explored presents generally uniform soil and bed-rock conditions. The sandstone

FIG. 18—View from same point as Figure 17 at 4 p. m. on clear day.

of the ridges and valleys is covered to varying depths with almost pure humus. On parts of the slopes and valleys it reaches a thickness of at least four feet. The crests of the ridges have a similar soil covering of a foot or less except at the scanty rock exposures. A few spots in the stream beds have sand mixed with the humic material. At Savana Hills the prevailing unstable humus gives way to firm ground formed of mixed sand and iron laterites.

A brief enumeration of various features of the mountain previously mentioned may help to throw light on its possible origin. Considerable time must have elapsed to allow the upper surfaces of the mountain, which are of unmistakable peneplain origin, to form. They slope back toward the interior of the mountain and terminate suddenly on the southeast face in an abrupt cliff which cuts irregularly across the intense folding of the resistant quartzites. Furthermore, it has been pointed out that the bases of the headlands lie in a comparatively straight line. It is difficult to conceive that the hard quartzites of the lowlands have textural differences sufficient to explain this discordance of the scarp with the initial structure. It seems worth while to make the suggestion here, subject to confirmation at some future date, that Cerro Duida owes its origin to block faulting.

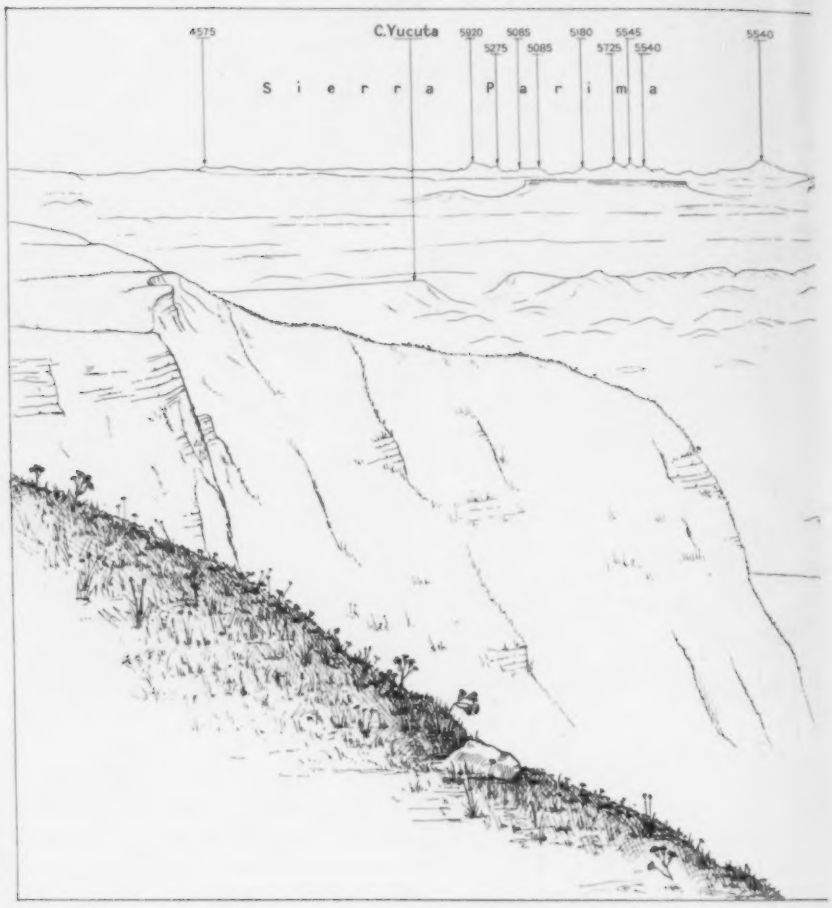
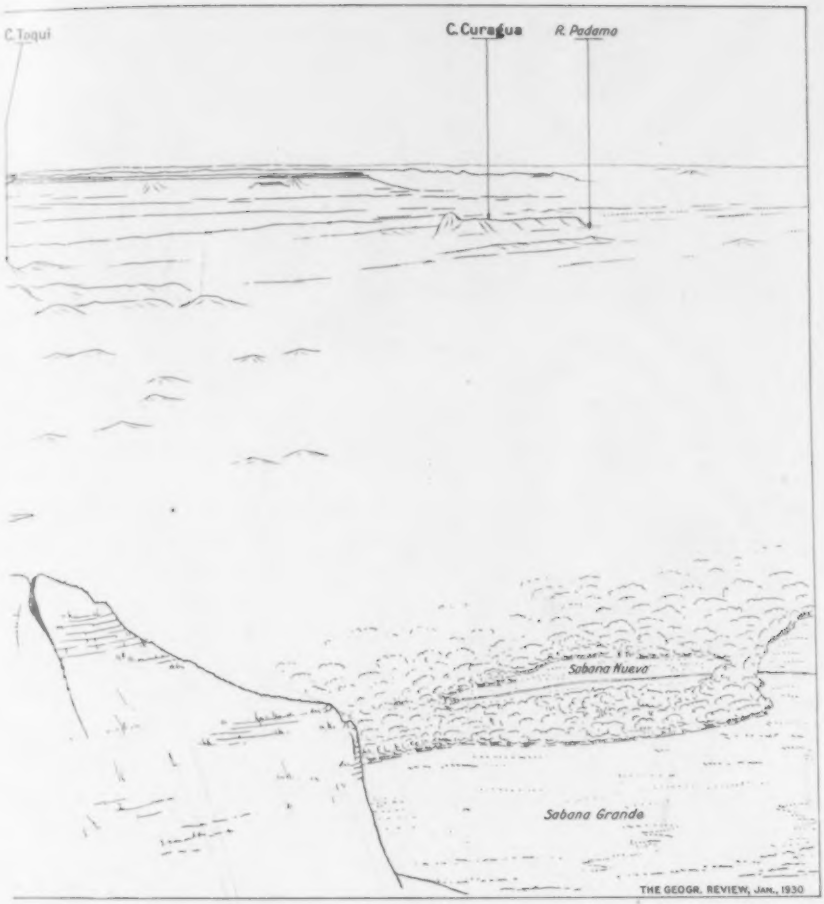


FIG. 19—Panorama sketched from High Point Camp (see Fig. 2) at the southern end of Duida.

WEATHER AND LIFE ON THE SUMMIT

November is still in the rainy period; December is drier, *los Nortes* coming at the end of it; January and February mark the height of the dry season; the end of February introduces the new wet season. The prevailing winds at Duida blow from the northeast; local eddy and convection currents form in all the deep valleys. Masses of cumulus cloud formed by upwelling, saturated air currents tower up over the cliffs on the eastern side for a thousand feet, overshadowing the first half mile of the edge and at times floating right across the summit. Cloud rises also up the western scarp but is blown away to the southwest as soon as it passes the top of the cliffs. The center of Duida is comparatively dry but becomes clouded over from time to time, and in the latter part of February wet afternoons and evenings are the rule. The number of hours of sunshine at the cliff



The view looks eastward to the Sierra Parima; southeast to the Sabana Grande. Compare Figure 20.

edge in November and early December were no more than one or two a day, while rain fell with great frequency, becoming a downpour almost every afternoon and evening. Three miles nearer the center, in the neighborhood of Central Camp, the sunshine increased to six or eight hours a day in mid-December and to ten or even twelve hours in January and early February. December to January temperatures at Central Camp (4900 feet) averaged 62°–63° at 6 a. m. and 65°–66° at 7 p. m. At High Point Camp (6900 feet) temperatures during January-February averaged five or six degrees lower.[9]

The conditions of intense rainfall, subtropical temperatures, and pure humus soil overlying sandstone have combined to produce a remarkable vegetation complex. The valleys are filled with tangled, moss-hung trees and bushes whose semi-recumbent trunks and

[9] Records on file at the American Geographical Society.

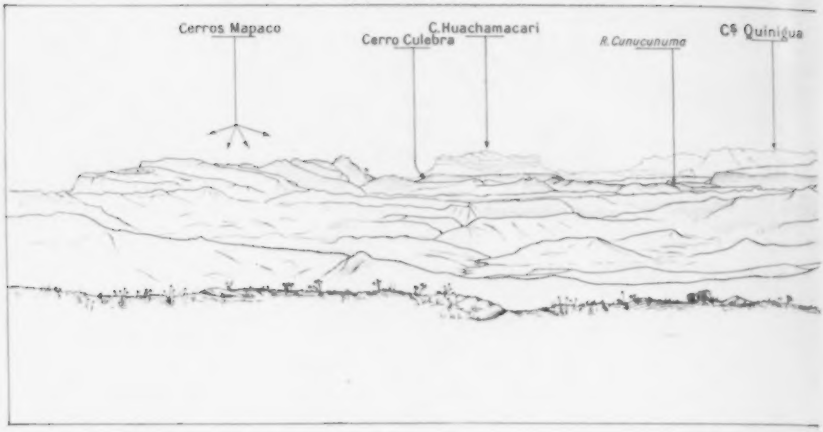


FIG. 20—Looking north over the dissected summit of Duida from the same point as in Figure 19.

branches interlace. The ridge slopes are similarly forest-clad but on a rather reduced scale. Crests of ridges are crowned either with interwoven wiry bushes or with close-packed mats or cushions of herbaceous plants. Many trees of the slopes and valleys conform to a type with thick, blunt branches, terminal whorled rosettes of leaves, and large, apical flowers, usually pink. The family Ochnaceae is well represented. Exposed rocky places produce a low heathy growth; and the few small marshy spots carry vegetation appearing not greatly different in its ensemble from normal heath-marsh growth elsewhere, except that genera and species are one and all new. Streams are lined with wiry, flood-resisting plants, and their beds support tough linear-leaved, rushlike mats of water weed.

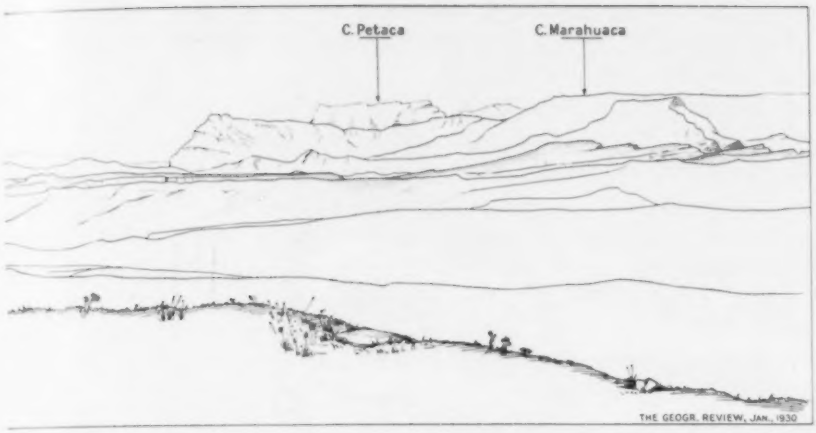
The Savana Hills laterites produce a number of plant forms not found elsewhere on the plateau—chiefly rocky, barren-ground and drought-resisting plants. Among dominant families are: Orchidaceae, Bromeliaceae, Xyridaceae, Rubiaceae, and Guttiferae.

Although richer and more diverse, the vegetation of Duida finds its nearest known allies on Mt. Roraima, some 400 miles to the east-northeast. As Dr. Gleason points out, study of the plant collections from Duida will shed much light on problems of plant geography in northern South America.[10]

Birds are numerous, comprising some 40 species, a number of which had not been described heretofore.[11] They include tanagers, finches, humming birds, tyrants, and ant birds. Mammals, except two species of rats, are very scarce. Opossums, coatis, tree porcupines, squirrels, and anteaters are occasionally encountered. Four kinds of snakes,

[10] H. A. Gleason: A Collection of Plants from Mount Duida, *Journ. New York Botan. Garden*, Vol. 30, 1929, pp. 166–168.

[11] Frank M. Chapman: Descriptions of New Birds from Mt. Duida, Venezuela, *Amer. Museum Novitates*, No. 380, 1929, pp. 1–27.



On the horizon are the distant peaks Huachamacari, Quinigua, Petaca, and Marahuaca (see Fig. 2.)

three of lizards, and several sorts of frogs were captured on the tableland. Fish are absent in the streams.

Subtropical insects of many orders are present, the colors of most of them modified in response to chill, humid climatic conditions to dark browns and blacks; although certain tropical butterflies—*Heliconius*—are encountered in the hot valleys toward the center of the mountain. Termites, quite distinct from the Esmeralda form, build globular nests among the rocks and on the drier ridges.

Distant Features

The following brief description of distant features is amplified by accompanying sketches.

From the high point at the southern tip of Duida a view is had of the whole horizon except where distant points are cut off by high portions of Duida itself. Beyond the Cunucunuma, which passes along the northwestern side of Duida and flows south into the Orinoco, stands Huachamacari (about 6400 feet), a layer-cake-shaped mass showing stratification. The Indians report small savanas, not only to the west of Duida but also at the base of the former mountain. North and northeast a mass of large mountains, including Petaca and Marahuaca with subsidiary hills, forms the continuation of the Duida group. In the distance through the gap between Huachamacari and the last-mentioned system high mountains named Cerros Quinigua possibly separate the drainage basin of the Cunucunuma River from the Ventuari. The horizon east-northeast and east is lined by the distant peaks of the Parima Mountains. To the southeast no prominent hills show on the horizon. Due south, however, is a series of serrate peaks volcanic in appearance and recognized only by one Indian. He called the largest Vijiya. A possible approach might

be by way of the Paciba River or the Siapa, left-bank tributaries of the Casiquiare. The rest of the horizon southwest, west, and west-northwest is without noticeable hills.

A low table-land in a line with the prominent peaks of the Parimas and a second, larger plateau farther to the south, showing well marked scarp faces at sunset, both appear to have altitudes of 3500 feet and to be some 35 miles away. Still nearer, numbers of parallel ridges with several prominent hills among them extend in a southeast direction. Although common mainly to the north of the Orinoco, a few lines of low, rounded hills continue across the river into the country on its left bank. In the shades of late afternoon faint parallel ridges can be seen below, running to the southeast through the lowland forest.

The land to the south is dotted with low, rounded hills. Moderately high hills stand near the junction of the Cunucunuma with the Orinoco and to its west. Beyond them, on the right bank of the river the only prominent mountain is Yapacana.

The Orinoco is very clearly seen coming in great meanders from the southeast to within ten miles of Duida. It then is diverted to a course approximately westward. The bifurcation at the inlet to the Casiquiare can be just distinguished, and the further course of the larger river is indicated interruptedly for many miles by occasional glimpses of water. The mouth of the Cunucunuma, either on account of forest or hills, is concealed. A low ridge called Guaraco, with scarp facing the Orinoco, parallels the southwestern cliffs of Duida. From fissures in this hill fire is reputed to appear every year during January and February. Two other places on the cliffs of Duida itself were pointed out as the spots where, even after heavy rain, fire always starts. This idea of mysterious light has been carried down from the days when Humboldt first visited Esmeralda.[12] During five and a half months' stay in the Duida region there was no mysterious beacon, and the only clues to the story are portions of slope burnt over by forest fires.

Inhabitants and Economic Conditions

The Indians who worked for the expedition, preparing trails, ladders, houses, and carrying baggage on their backs, usually gather balata for two local employers during the wet season and cultivate their *canucos* during the summer. They belong to the Maquiritare tribe, formerly living in large numbers up the valleys of the Cunucunuma and Padamo rivers. We were given to understand that many of them have recently migrated from the Cunucunuma to the Guainia and come back each year through the Casiquiare to work. We employed some twenty to twenty-five men and were informed that it

[12] See also Richard Spruce: Notes of a Botanist on the Amazon and Andes, edited by A. R. Wallace (2 vols., London, 1908), Vol. 1, p. 402.

would be difficult to secure more; so that probably the number of Indians, men and women, in the neighborhood does not exceed two hundred.

In intelligence the Maquiritaris rank quite high, and seldom can better and more untiring workmen be encountered. They were cheerful even on the top of the mountain where they were unable to sleep on account of the cold and had to exist for days together on manioca and a little dried meat.

The upper Orinoco contains a certain amount of Brazil nuts, balata, and rubber. The balata is worked during the rainy season from April to August and is shipped either to Manáos or Ciudad Bolivar. A German from the latter city has established a habit of traveling up river in a large *piragua* to buy the balata crops from any who care to sell to him. An inferior grade, called *pulga negra*, grows abundantly in the Duida region but is valueless commercially. The latex is heavier than that of balata and cracks when dry. Owing to the lower price of rubber the gum is no longer collected. Brazil nuts are said to be plentiful farther upstream, but their distance from a market prevents profitable harvesting. Although forbidden by law the natives persist in cutting down the balata trees instead of tapping them, in order to secure greater quantities of latex. Consequently the supply of balata along the various affluents is becoming rapidly exhausted.

APPENDIX

Construction of Map

The map was constructed with plane table and compass traverses. A telescopic kern alidade, having vertical circle reading to minutes and equipped with parallel ruler, was used in conjunction with the plane table mount developed by Mr. O. M. Miller of the American Geographical Society. The mount, which has been previously described,[13] consists of an aluminum frame upon which specially prepared aluminum-backed sheets can be mounted by thumbscrews at the corners. These sheets weathered the tropical climate remarkably well and proved easy to transport.

Two surveying aneroids were taken. One of these was found to be giving erroneous readings soon after we reached Esmeralda and could not be used. The other, on our return to New York, was tested and shown to be in order. A Brunton compass was used.

Vertical angles were figured from tables issued by the School of Surveying of the American Geographical Society.[14]

A base line 4000 feet long was measured on the Esmeralda savana and extended to two low hills. From these stations, which paralleled the southeastern scarp of the mountain, rays were taken to a number of points. The astronomical position (lat. 3° 10′ 14″ N.; long. 65° 33′ 30″ W.) and height above sea level (324 ft., 99 m.) determined by Dr. A. Hamilton Rice were used to tie in the map.

[13] O. M. Miller: The 1927–1928 Peruvian Expedition of the American Geographical Society, *Geogr. Rev.*, Vol. 19, 1929, pp. 1–37; reference on p. 36.

[14] Tables for the Approximate Determination of Heights and Distances, *Amer. Geogr. Soc. Publs. School of Surveying Ser. No. 5.*

From the summit the table was reoriented with fair success. However, it must be noted that a large triangle of error was formed in locating the station in the center of the mountain.

The calculated altitudes and the aneroid agreed within 400 feet. The former averaged somewhat higher than the latter.

From two points four miles apart on the southeastern cliffs, rays were taken to different points on the horizon. The following method was used. A separate sheet was used for each station; rays were drawn to the various points, and vertical angles recorded; an orientation line was drawn from a trough compass. From the second station occupied a ray could be drawn to the first point. On our return to New York the azimuths of the rays were measured on a micrometer protractor. The distance on the field sheet between the two points was measured, and the distances and vertical angles calculated. In valuating these positions, therefore, account must be taken of these various processes, which can produce a considerable error.

The original plane table maps, on a scale of 1 : 100,000, were reduced in compilation to 1 : 250,000. Magnetic north was considered as true north. The expression of the western foothills, owing to lack of information, is schematic.

NOTES ON THE MOUNT RORAIMA REGION

G. H. H. Tate

American Museum of Natural History

[With separate map, Pl. I, facing p. 68]

STANDING some 400 miles east by north from Cerro Duida, at the opposite end of the Parima Range, the series of separate table-lands composing the Roraima Mountains present certain marked likenesses and contrasts. Both are table mountains, steep-sided and formed of sandstone. Schomburgk, when he traveled from Roraima to Duida along the Parima Range, was struck by the considerable resemblance of the two and suspected that the rock forming Duida was similar to the sandstone of which Roraima is composed. Both mountains have a cool, rainy climate; and their peculiar fauna and flora show marked affinities.

On the other hand the strata of Duida are intensely folded; those of Roraima being level-bedded. Duida rises over 6000 feet from a peneplain 325 feet above sea level and has a surface area of some 250 square miles. Roraima attains 8600 feet but rises from dissected, rolling savana lands 4000 feet above the sea and probably does not exceed 25 square miles in area. Duida appears to be a newly up-faulted mass, perhaps still rising, while the Roraima Mountains seem to represent only the remnants of a once vast table-land. Duida has a deep covering of humus and bears a complex and highly modified fauna and flora; while Roraima is almost devoid of soil and is the home of a relatively small and apparently diminishing plant and animal population.

Sir Everard im Thurn well stated the attractions of Roraima in describing the plans for his expedition of 1884 and summarizing the work of the earlier explorers.[1]

> An extraordinarily large number of its plants are peculiar to Roraima, and almost all of them are of unusual beauty, or are strange in form, or perhaps both. . . . As with the flora so with the fauna, except that the latter though equally peculiar seems to be by no means so abundant. . . . Roraima stands in a true wonder-land, filled with things rare and beautiful and strange.

Since im Thurn, several others, mostly naturalists or boundary surveyors, have visited Roraima; and some have repeated the ascent,

[1] Everard F. im Thurn: Mount Roraima in Guiana, in "Proceedings of the Geographical Section of the British Association, Montreal Meeting, 1884," *Proc. Royal Geogr. Soc.*, Vol. 6, 1884, pp. 667–674. For an account of the expedition see *Idem:* The Ascent of Mount Roraima, *ibid.*, Vol. 7, 1885, pp. 497–521, and H. I. Perkins: Notes on a Journey to Mount Roraima, British Guiana, *ibid.*, pp. 522–534.

FIG. 1—The cliffs of Mt. Roraima. The view is taken from the summit and looks down on the ledge.

but few have made more than the briefest stay on the summit.[2] To make as complete a collection as possible of the flora and fauna of the mountain as a whole and its region was the object of the Lee Garnett Day Expedition of the American Museum of Natural History in 1927–1928, of which the writer was a member and which spent from November 17 to November 29 on the summit.

Savanas of the Rio Branco Region

The expedition entered the region from the south by way of the Branco River, the approach used by Koch-Grünberg in his memorable journey from Roraima to the Orinoco.[3] In the Rio Branco savanas there is only one town of importance, Boa Vista, lying a short way south of the junction of the rivers Tacutu and Uraricuera. It was occupied as his base by Dr. A. Hamilton Rice during his recent expedition, and good accounts of the region may be read in several papers.[4]

In every direction the land is ancient peneplain with here and there granite bosses projecting through its surface. It extends eastward to the Ireng River (Mahu on Brazilian maps) and as far north as the Humirida Mountains. The soil alternates between clays and quartz sand, with restricted small areas covered by quantities of quartz crystals. The surface is generally level, but there are slight depressions which, coupled with an imperfect drainage system, give rise to extensive swamps, the homes of many species of wading and swimming birds.

The prevailing vegetation of the savanas comprises grass and sedges of low fodder value and scattered low bushes and trees, the most characteristic being *Curatella americana* L., whose leaves are so harsh of surface that they are said to serve for sandpaper. In the swamps and bordering the brooks *Mauritia* palms form the dominant feature, but they are supported by lesser plants of great variety; while along the borders of the larger rivers grow narrow fringes of gallery forest. At Frechal, where the land shows some uplift, rather extensive, though low and very open forest is found; and on the slopes of granitic hills

[2] On the second expedition of F. V. McConnell and J. J. Quelch (1898) "nine days of continuous exploration" were engaged in on the summit of Roraima. See Charles Chubb: The Birds of British Guiana, 2 vols., London, 1916 and 1921. The itinerary of the second expedition is described in Volume 2.

[3] Theodor Koch-Grünberg: Vom Roroíma zum Orinoco: Reisen in Nordbrasilien und Venezuela in den Jahren 1911–1913, *Mitt. Geogr. Gesell. in München*, Vol. 12, 1917, pp. 1–79. Also his five-volume work of the same title, Berlin, 1917–1923.

[4] Richard P. Strong and Others: Medical Report of the Hamilton Rice Seventh Expedition to the Amazon, in Conjunction with the Department of Tropical Medicine of Harvard University, 1924–1925 (Contribs. Harvard Inst. for Tropical Biology and Medicine, No. 4), Cambridge, Mass., 1926, Part III.

A. Hamilton Rice: The Rio Branco, Uraricuera, and Parima, *Geogr. Journ.*, Vol. 71, 1928, pp. 113–143, 209–223, and 345–357.

Albert W. Stevens: Exploring the Valley of the Amazon in a Hydroplane, *Natl. Geogr. Mag.*, Vol. 49, 1926, pp. 353–420.

like Serra de Marauahy with its piled-up masses of rock fragments and boulders a xerophytic flora with straggling low bushes, globe cactus, and dogbanes exists.

Miang Valley and Humirida Mountains

The termination of the lowland savanas is roughly in latitude 4° 10′ N. The Humirida Range, which runs from west to east, has a fringe of granite hills along its southern edge—the Serra do Mel, Serra de Mairari, and hills just to the north of the village of Contão. An increase of rainfall causes a correspondingly greater luxuriance of vegetation everywhere among the hills except on their southern slopes, which have plants similar to those of Serra de Marauahy.

The basin of the Miang River between the fringing hills and the Humirida Mountains proper, however, has very heavy rainfall and contains great areas of woods quite as tall and dense as Amazonian forest alternating with patches of open country. The distance from the Humirida to the Serra de Mairari is about fifteen miles.

On the northern edge of the Miang Valley the Humirida forms a steep wall giving every appearance of a fault scarp, with forest-filled ravines running up it. The rock forming the lower parts of this range was not determined, but that of the actual crest is a sandstone. The top of the range is partly forested, though chiefly covered with open savana. From it a view is obtained of the Roraima Mountains, some forty miles to the north. A beautiful red rock orchid (*Habenaria decipiens* Lindl.), very common at the foot of Roraima, was seen for the first time growing on the sandstones of the summit of the Humirida Range. The northern slope is gradual, leading first to the Catá and Wailing rivers, small streams tributary to the Kukenam (Cuquenam), and then across cross-bedded, jointed sandstones into the Kukenam Valley.

Wherever sandstone is actually the surface rock no forest seems to grow; on the contrary, the exposures of diabase, weathered down to lateritic clays, support magnificent woods. For example, the northern slope of the Humirida, with a soil of red-brown clay is heavily forested and rich in balata trees, but the crest of the range and the land just beyond the slope to the north are both sandstone and mainly without forest.

The trail winds down the Humirida slope, crosses the Catá and Wailing rivers, and climbs a succession of south-facing bluffs of cross-bedded conglomerate, passing gently down the five-degree slope of each to confront the next one, reaching finally the valley of the Kukenam. The deflection of the river here from its original southward course westward to join the Caroni may mark the position of a fault.

The sandstones both of the summit and just to the north of the

Humirida Mountains show a high degree of cross-bedding. The rock, jointed into polygons six or eight inches in width, suggests that the region has at some time been subjected to great dynamic stresses. No trace of fossils could be discovered either here or later in the sandstones of Roraima.

The Laterite Savanas South of Roraima

About two miles north of the river and still some thirty miles south of Roraima a steep sandstone escarpment with beds striking west-northwest and dipping about three degrees north is encountered. The dip may be slightly less than that of the Humirida sandstones. These rocks rise nearly 500 feet above the Kukenam plain. The exposure shows red sandstone much interbedded with a fine, claylike white sandstone.[5] The white beds vary in thickness from less than an inch to nearly three feet. Cross-bedding in this series seems rarer than in the Humirida beds farther south. At the top of the scarp the sandstone is found overlain by laterite, which continues in an unbroken sweep to the Roraima Mountains.

Derived from nearly homogeneous volcanic sills, the soils of the upland savanas are remarkably alike. In places the ridge tops are deeply covered with large or small clinker-like stones that look as though they had been sifted from furnace ashes. These nodules, through the washing out by rain of all finer soil, lie concentrated on the summits of the ridges. They are believed to be a product of weathering of diorites, gabbros, etc. On the hillsides the soil is a densely compacted brown or red laterite clay whose every loosened particle is at once carried away by the tremendous wash of the rainfall. The entire surface of a slope is sometimes to be seen covered to a depth of an inch with swiftly running water. In the valleys and in cuplike hollows on the slopes the soil is accumulated and becomes mingled with considerable portions of humus so that it forms the excellent forest-producing soils of the region. The laterites proper, then, except for occasional large pieces cut out by rainwash and carried down into the bottoms, are confined to the uplands.

The topography of the next thirty miles of country to the north is youthful, the valleys being in an early stage of the erosion cycle. A medley of ravines from one hundred to several hundred feet in depth, separated from each other by high, narrow ridges, must be crossed.

The road leads northward along the ridges between the valley of the Kukenam and the basin of the Caroni to the west. Much of this

[5] This type of rock was discovered first in the escarpment just north of the lower Kukenam River near the Brazilian Pakaraima Range interbedded with sandstone. It is found again in the bed of the Kukenam River a few hundred yards upstream from Paulo village. Outcroppings exist all the way down the steep descent of the eastern spur of Weitipu into the Cotinga Valley; and close to the top of the great 800-foot hill to the east of the Pipi River it shows again.

FIG. 2—The southern end of Roraima, showing the "pinnacle" named by the Arecuna Indians "Towashing," seen from Paulo.

basin is in a more mature condition; and some ten miles westward the land seems a fairly level plain for the most part under a heavy forest cover. Far beyond, however, sandstone formations can again be recognized.

The dry season, although by no means so severe or prolonged as that of the Rio Branco country to the south, is fairly pronounced in the upland savanas (3000 to 4000 feet). In October, afternoon showers and thunderstorms are frequent.

A trail leads directly toward Mt. Kukenam until within eight miles of it, then turns northeast along its foot to where its slopes and those of Roraima merge. Base camp was formed here at the Arekuna village of Paulo (Kavalianalemong of Koch-Grünberg, Tekwonno of Clementi).[6]

The village consists of about six community houses inhabited by a fluctuating population, varying from twenty to forty, of Arekuna Indians. The chief, an old man, calls himself Schoolmaster.[7] The huts are built at the tip of a ridge of barren laterite that never has supported forest but carries coarse, drought-resisting grasses and sedges of the savanas.

THE MOUNT RORAIMA REGION

Roraima is approached from south-southwest across some forty miles of broken, hilly savana land. Woods are confined to deep valleys whose meanders cut the rolling savana in every direction. Country of this type is representative for the entire region of the Arabupu, Kukenam, and part of the Caroni and Cotinga drainage

[6] Mrs. Cecil Clementi: Through British Guiana to the Summit of Roraima, London, 1920. *Idem:* A Journey to the Summit of Mount Roraima, *Geogr. Journ.*, Vol. 48, 1916, pp. 456–473.

[7] The Arekunas of the region occasionally work for short spells in the Guiana diamond fields in order to obtain the cloth, knives, powder, and trinkets given in payment. Presumably they adopt the English names there given them.

basins. A series of high ridges running from Roraima and Weiassipu first east and later southeast marks the northern extent of the savana country. They separate the headwaters of the Cotinga (Kwating) and Ireng from those of the Mazaruni and Potaro rivers.

FIG. 3—Looking north from Arabupu. The northeast corner of Mt. Roraima and the isolated sandstone fragment, Weiassipu.

The Roraima Mountains, of which Mt. Roraima is the largest and Kukenam the second, form a series of remarkable flat-topped masses of quartzite whose sides are usually sheer precipices more than a thousand feet in vertical height. These blocks of pink quartzite rest like caps upon the remains of a thick sill of diabase[8] weathered into uniform slopes.

Beginning at the base close to the contact with the diabase sill and passing gradually up to the summit, the sandstone changes from excessively dense, indurated quartzite to a rock that, while still usually very hard, is more porous than that below. Owing to differential hardness some of the beds weather out much more rapidly than others. The maintenance of the "table" feature is accounted for by this unequal weathering.

The sandstone varies slightly in color, being banded white, red, and pink. The most usual color is a rather dull pink, especially in the lower strata. The sand composing the lower beds appears to be generally finer grained than that of the summit. Cross-bedding and current ripple marks are very common. On the summit of the mountain literally acres of ripple-marked rock are exposed. There appears to have been considerable dynamic stress upon the sandstone. Most of the joint cracks run nearly east and west, but a more defined set extend from the north-northwest to south-southeast. The slopes

[8] The decomposed, deeply eroded remnants of a diabase sill underlie the laterite-covered lands between the Roraima sandstones and the ring of similar beds sweeping from the Brazilian Pakaraimas, via Kowatipu, to Kaieteur and the Mazaruni escarpment. The greatest thickness (3400 feet) is found only at Roraima.

FIG. 4

FIG. 5

FIG. 6

FIG. 4—Sandstone cliffs resting on a dissected sill of diabase, seen from Philipp Camp (5200 feet).

FIG. 5—Rondon Camp, in the cloud belt (6900 feet).

FIG. 6—Arabupu Falls. The jointed rock in the foreground is "jasper." The hills are of diabase, with a laterite soil covering. Note the mixed savana and forest.

reach out and down from the contact with the quartzite (7400 feet) for a distance of about five miles to the savanas and on their upper parts bear the greater part of the specialized flora and fauna whose collection was one of the objects of the expedition.

The sill of diabase rests upon so-called green "jasper,"[9] which is exposed only in the beds of deep-cutting streams at about 4000 feet. The tendency of the "jasper" to break up into perfect rectangles of various sizes with joints vertical to the surface is nowhere better shown than in the Arabupu River (Fig. 6). This vertical jointing aided by the water has resulted in the beautiful Arabupu Falls, thirty feet high. In the streams that run west and northwest from Mt. Weitipu the same material forms the stream beds. All the "jasper" observed near Mt. Roraima is of the green variety, weathered at the surface to a light gray. In the streams farther east the red form[10] is said to be more prevalent. On the present occasion very little red "jasper" was noted.

[9] From a thin section Professor R. J. Colony of Columbia University has determined the rock to be devitrified volcanic ash.

[10] Clementi, Through British Guiana, pp. 166, 170, 172, and 177.

There is little doubt that the various members of the Roraima Mountain group are parts of the same geological formations. West-northwest of Roraima and Kukenam a row of three other mountains, Charantipu, Ualacatipu (Waika-piapu), and Urutipu (Irutipu) reach out for some twenty miles, thence ridges extending northeast cut off the Mazaruni and Cuyuni from the Orinoco drainage; and fifteen miles southeast an outpost, Weitipu (Serra do Sol on Brazilian maps), sits astride the 3000-foot ridge extending southward to Mt. Sapõ (Chakbang of Clementi, Sabang of Rice) and the Humirida.

Possibly the Merumé Mountains and Mt. Twek-Kway[11] visited by Whitely, form part of the Roraima series. The Merumé Mountains stand about thirty miles to the northeast of Roraima, between the Mazaruni and Potaro systems, and join the eastward-running ridges from Roraima somewhere near the origin of the Ireng River. Twek-Kway lies west of the Merumé Mountains and the Kako River.

About the land to the north of Roraima there is less information. Only some thirty miles away, the Kako and Mazaruni and their affluents capture the entire northern run-off of the Roraima Mountains. Accounts agree that no savanas exist to the north. Observation from the summit of Mt. Roraima bears out this statement; no trace of savana interrupts the sea of forest stretching northward from the foot of the cliffs.

Mount Roraima

The sandstone plateau of Roraima, 8600 feet above sea level, 1200 feet higher than its pedestal of diabase, and having a summit area of about 25 square miles, forms the nucleus of the Roraima Mountain group and may be considered representative both geologically and biologically of the entire system. From the southwestern side its summit can be reached with comparative ease by way of an oblique ledge running from base to crest of the cliffs. The ledge is the only known way of reaching the top. The necessary eight to ten miles of approach trail from Paulo to the foot of the ledge can be opened without great difficulty.

In two places the slope of diabase is interrupted by relatively small sandstone escarpments. Both are on the southwest side, one beneath the "Pinnacle," an isolated portion of the cliff at the southern tip of the mountain, the other almost directly below the upper part of the ledge. The northeast wall of Kukenam, visible only from the summit of Roraima, has a similar scarp with much the same thickness and elevation as those on Roraima. So, locally there may be two sills of diabase one above the other, perhaps resulting from transgression of

[11] The Merumé Mountains are briefly referred to in Henry Whitely: Explorations in the Neighbourhood of Mounts Roraima and Kukenam in British Guiana, *Proc. Royal Geogr. Soc.*, Vol. 6, 1884, pp. 452–463. On the visit to Twek-kway see *ibid.*, Vol. 8, 1886, p. 453.

molten rock from one sandstone horizon to another, and a comparatively thin series of beds left between them. The upper sill is only a few hundred feet in thickness, the intervening sandstone 200 feet, and the lower sill about 2000 feet. The slopes are in general covered with laterite, but the practically unaltered diabase on which the sandstone caps rest forms the nucleus of each projecting ridge.

The Ledge

Seen from a distance of five miles, the ledge leading to the summit appears an irregular, blackish line slanting upwards from right to left across the red wall of rock. Nearer, it appears covered with steeply sloping débris where a slip of the foot may mean death. The reality is quite different. In many places, so large is the scale on which the feature is built, one would never guess he were part way up the walls of Roraima, for, although there is a steep outward slope, the effect is merely that of hillside forest. Mist intensifies the impression by allowing only near views of the surroundings.

The walk from the foot of the ledge, 7400 feet, to the summit 1200 feet higher, over a well prepared trail takes about an hour. There are two main dips some fifty or a hundred feet in vertical extent in the upward course: the first is met about halfway up, the second some three-quarters of the way. One spot on the rise between the two dips is rather difficult. It can be surmounted by constructing a rough ladder about fifteen feet high, or it can be avoided entirely by passing below it.

At the bottom of the second dip a waterfall from the top of the cliff showers down onto the ledge. Just past the cascade is a series of steplike strata covered with slippery moss, rather dangerous to traverse. The trail then leads up among some little trees for about fifty feet. The rest of the climb, some fifteen minutes in duration, is through a mass of screes and tumbled boulders.

During extremely heavy rain a waterfall gushes from a hole in the cliff and pours onto the ledge at its lower end, making the trail quite impassable. Generally, however, the only waterfall is the small one already mentioned near the top.

The Plateau

At the top a troughlike cleft in the rocks bordered by a vast jumble of weathered masses of blackish sandstone leads forward from the ledge for fifty yards. It appears to be a joint fissure filled with humus and is marked by the swamp vegetation growing along it. The trough opens on an elongate, shallow amphitheater about a quarter of a mile in length. There is scarcely a level place anywhere, but the rock is sculptured by weathering into a thousand different forms. The

walls of the natural arena are formed of tier upon tier of turreted light-red sandstone blackened by some sort of alga growing over it. Owing to unequal hardness of the beds, the table-mountain feature is reproduced not only in the *morros* that ring the arena round but endlessly down to tiniest little mushroom-shaped rocks. The amphitheater of rock, hemmed in by the block-shaped *morros* to north, west, and east, is only a small corner of Roraima. From the top of one of the *morros* a view is afforded of the real plateau—the interior. It is then noticeable that the *morros*, with the exception of a group of six at the center, are confined to the northern part of Roraima, forming a more or less bordering fringe near the top of the ledge and across to the northeast becoming so numerous that that part of the plateau appears positively to bristle as with so many great teeth (compare Figs. 8 and 9).

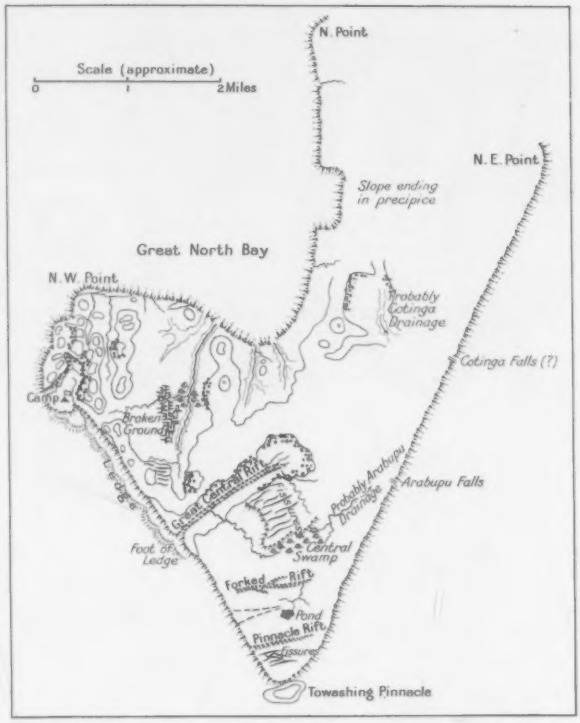


FIG. 7—Sketch map of the summit of Mt. Roraima.

A striking and unexpected feature is a great embayment cutting back into the mass of the mountain from the northwest. Its width across the mouth appeared to be about two miles, but it was so generally filled with white cottony cloud that its size could be estimated only with difficulty. From the northwest point, north of the ledge, a view is afforded of the knife-edge linking Roraima and Kukenam. Its northern side is very much steeper than that towards Paulo. The entire northeastern wall of Kukenam, with an "island" lying off its northern tip, is visible; and on exceptional days, when breaks occur in the upwelling mist, another table mountain, possibly the northern end of Charantipu, is seen. Virgin forest fills not only the gulf between the twin mountains but invades the floor of the northwest bay. Suggestions of rivers glisten white amid the greenery far below.

Almost all the rock near the edge is indescribably splintered and cracked. For this reason the border of the precipice can be reached at only a few places. Crevasses from a yard to several yards in width and of unknown depth bar the way. They commenced perhaps as joint cracks, and the ubiquitous water with its load of sand grains scoured them rapidly wider and deeper. At the tapering end of the plateau, near the "pinnacle," the joint cracks frequently cross completely from side to side of the mountain, and water from the surface, after pouring into such rifts, reappears gushing from the face of the cliffs. Usually the crevasses are narrow enough to jump across, but in several places the only way of passing from side to side is over a natural bridge formed by some boulder caught between the walls. The largest of the rifts has weathered laterally near the surface of the plateau to form a valley about a hundred yards in width. It is composed of several minor crevasses.

In general the interior plateau looks flat and monotonous. Appearance is deceptive, for there are actually very few places where walking is not difficult, and these follow the joint system of the sandstone. For the most part, tumbled masses of rock, rifts, and gorges and whole acres of ten-foot mushrooms and loaves of bread formed in stone offer a maze in which one may wander long before finding better ground; while gullies many yards in depth and breadth, meandering undecidedly, force detours of sometimes half a mile. Almost nothing of this can be seen from the top of a *morro*.

In a few fairly level places the sandstone disintegrates, and water-soaked, level stretches of sand are formed. The largest of the swamps is a little south of the center of the mountain. It is about 150 yards long and 50 broad. Concentrations of humus in the shallower cracks and rifts form a second kind of swamp. These humus bogs are treacherous and, when deep, dangerous. Sedges, sundews, pipeworts, and bladderworts grow on their surfaces.

The Collecting Stations

The lowlands about Roraima are scantily peopled by the Arekuna (Jarecuna of Brazil) Indians who inhabit the basins of the Cotinga, Kukenam, and Caroni rivers. They have a deplorable custom of setting fire to the grasslands of their territory. The fires sweep over hundreds of acres of savana annually and, entering the forests, destroy or greatly alter the component vegetation of large tracts. Great regret was felt on finding that two years before the arrival of the expedition, during a period of extreme drought, the greater part of the forests of the diabase slopes of Roraima had been completely destroyed. The fire had even reached the plateau by way of the ledge but had made no progress in the scanty vegetation. On the slopes sufficient

FIG. 8

FIG. 9

FIG. 8—Summit of Mt. Roraima. The rocky basin or amphitheater surrounded by castle-like *morros*.

FIG. 9—Summit of Mt. Roraima. Typical aspect of the barren interior of the Roraima plateau.

surviving pockets of forest at various altitudes were discovered for the assemblage of collections representative of the rich fauna and flora that existed before the fire.

Paulo was chosen as a station by the expedition for its convenience at the foot of the trail to the summit rather than its value as a collecting site. The altitude of Paulo is 4000 feet. The temperature at 6 a. m. in the latter part of October and early November averaged 64° F.;[12] clear and rainy days alternated. Above Paulo three camps were established: Philipp and Rondon Camps, named for the Rondon Commission, and Summit Camp.

General Rondon, in whose company the expedition had traveled from Limão, and whose party preceded the expedition to the summit, had selected Philipp Camp, five or six miles from Paulo, as the best on the slope. It lies at 5200 feet in a little sandy plain cupped in a hollow of the hills. A stream of clear water flows not fifty feet away from the camp site. Numerous great sandstone boulders are strewn about, the tops of which support certain rock-loving plants and also afford splendid views across the broad valley of the Kukenam and the rolling hills beyond. Philipp Camp is characterized by being prevailingly a high savana station. It is close to the apex of a tongue of grassland bordered by burned forest extending directly up the slope to an elevation of 6100 feet. The temperature at Philipp Camp from November 8 to 14 averaged 61° at 6.30 a. m.; rain fell on most afternoons and evenings.

Rondon Camp was established at 6900 feet. As no level ground was to be found here, the camp was fitted in amongst the boulders as well as possible. A large patch of uninjured cloud forest at 7000 feet furnished the greater part of the collection from the region. Moreover, from Rondon Camp it was possible to explore the remaining 500 feet of mountain slope up to the base of the cliffs. These forests undoubtedly contain most of the endemic types of fauna and flora for which the slopes of Mt. Roraima are noted. The number of hours of rain daily, only half a mile from the cliffs, must be at least twice as great as at Philipp Camp, and, owing to the manner in which mist persistently mantles the precipices and the slopes near their base, the humidity remains close to saturation point. The average temperature at 6.30 a. m. from December 1 to 5 was 59°.

Roraima is normally surrounded by a cloud belt which wells up shortly after dawn on all sides and from time to time rolls across the plateau. The central part of the table-land averages more hours of sunshine than the edges, and often when the mountain appears completely obscured from the lowlands the center is bathed in sunlight. However, the rainfall is very great, there being little fixed

[12] Koch-Grünberg records the following temperatures for late September and early October (1911): 61° at 6 a. m., 79.5° at 2 p. m., 66.5° at 9 p. m.

rule for the time of precipitation. It may rain at any hour of day or night or all day and all night.

At Summit Camp, 8600 feet, the temperature at 6 a. m. from November 17 to 29 averaged 52° and once sank as low as 50°.[13] Through the day, if there was any sun, the temperature registered well up in the seventies, although one day it did not rise above 54°.

On the eastern side of Roraima a station was formed at Arabupu, 4000 feet, where forests have been less injured and environmental

FIG. 10—Looking southeast from Arabupu. Mt. Weitipu across the Weitipu forest.

conditions are essentially the same as must have prevailed at Paulo before the fire. Arabupu has a population of about fifty under a chief named Isaac. The Arabupu River (Arapapé on Brazilian maps) begins as a thin, silvery cascade falling from the cliffs of Roraima near the middle of the southeast wall and joins the Kukenam some twenty-five miles to the south. Its valley is broad, chiefly savana-covered, bordered on either hand by rolling hills from which issue numerous tributary streams. A mile or so to the north of the village, however, the grasslands terminate. To the southeast after half an hour's walk from camp, the border of the great forest of Weitipu, stretching unbroken for some ten miles to the northern slopes of the mountain of the same name, is reached.

FROM RORAIMA TO THE POTARO RIVER, BRITISH GUIANA

On January 9, 1928, the expedition left the Roraima region and returned by way of British Guiana. Earlier explorers reached the mountain through British Guiana via the Mazaruni or Rupununi rivers. Im Thurn first entered via the Potaro River and Kaieteur Falls route, which has subsequently been followed by most expeditions. Various trails have been followed on the upper savana above the falls. The Clementis (1915–1916) traveled via the village of

[13] Quelch reports minimum temperatures of between 44° and 47° on Roraima during October, 1898: the difference between his readings and ours is rather surprising.

Puwa and rounded Mt. Kowatipu on the south, whereas the present trail holds more to the north and passes north of Kowatipu.

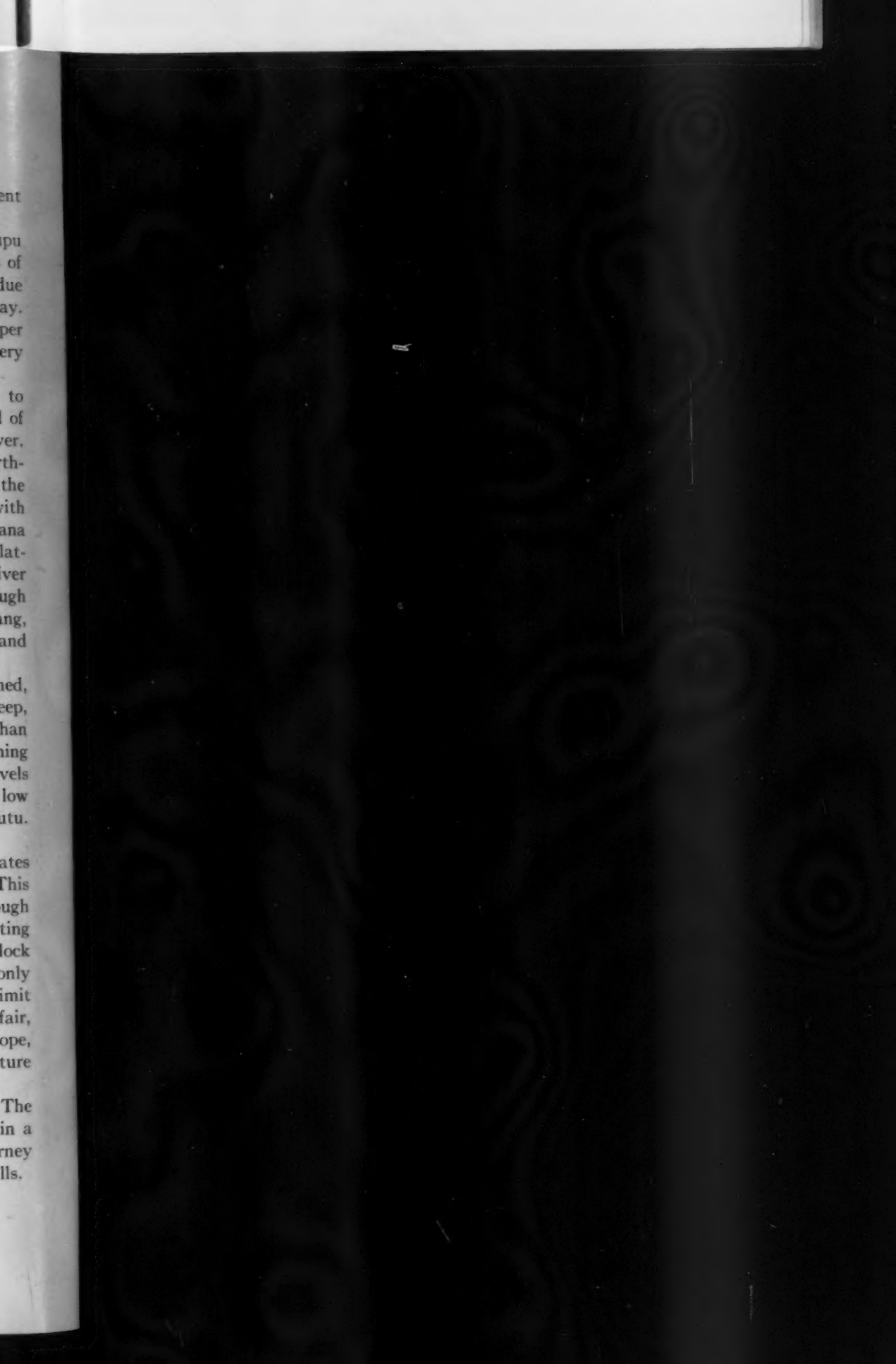
From Arabupu village the trail goes down the valley of the Arabupu River, crossing several small tributaries, all of them having beds of green "jasper," skirts the western spurs of Weitipu, and turns due east around its southern end, keeping to the open savanas all the way. On the second day the broad but still youthful valley of the upper Cotinga is reached. The side of the valley towards Weitipu is very steep—about 1000 feet in height.

East of the Cotinga an undulating laterite country extends to the valley of the Pipi River, a small tributary. The eastern wall of the Pipi Valley is also steep and rises some 800 feet above the river. From its summit the entire quadrant of land from Roraima northward and northeast is seen to be elevated—this being, in fact, the eastern offshoot of the Roraima Mountains linking Roraima with the Merumé Mountains and the ridges that run along the Guiana boundary. In the Pipi highlands humid forest alternates with laterite savanas but becomes less abundant beyond the Wailang River (not the Wailing of the lower Kukenam), whose course is over a tough igneous rock rich in dark minerals. Six miles farther the Caranang, passing over laterite and "jasper" is crossed. Both the Wailang and the Caranang are said to flow into the Ireng.

In the fifth day the western edge of the Ireng Valley is reached, marking an abrupt transition from undulating high savana to steep, heavily forested slope. The woods, clothing a descent of more than 1000 feet, resound with the whistling of gold birds and the chiming of innumerable bell birds. The Ireng, nearing the end of its travels among the hills, comes out some forty miles farther south into low savana country of the Rio Branco region and unites with the Tacutu. It forms the boundary between Brazil and British Guiana.

A high dividè of sandstone, with a summit of open savana, separates the headwaters of the Potaro from the valley of the Ireng. This water parting continues interruptedly to Dutch Guiana, although near the source of the Rupununi it is practically nonexistent. Resting on it near Kaieteur is Mt. Kowatipu, a flat-topped sandstone block essentially like Roraima but smaller and reaching an altitude of only some 4000 feet. The top of the ridge marks the northeastern limit of savana country. It also terminates the region of prevailingly fair, dry-season weather of the upland savanas; for the Guiana slope, forested nearly to the coast, receives continuous supplies of moisture from the northeast trade winds.

The territory in the Potaro headwaters is hilly and dissected. The main affluent of the Potaro, the Chenapowu River, is reached in a two-days' journey from the crest of the divide, and a day's journey downstream in a canoe suffices to reach Kaieteur Plateau and Falls.



BRITISH GUIANA
VENEZUELA
Haiamatipu Mt.
Waioklepaluta
Ayanganna Mount.
Kukui River
Ainoko-Kopai
Kukui Mt.
Kukuipia
Wupaima Mt.
Aromatipu Mt.
Mountains
Ingarikoima
Pakaraima
Cº Irutipu
Cº Carauringtipu
Cerro Yarcuruima
Cerro Waika-piapu
Mt. Iwalkarima
Mt. Ayangcatsibang
Cº Charantipu
Wei-assipu.
Mt. Appokaitang
Mt. Marinama
Mt. Yakontipu
Cº Manawarai
Cuquenam
Cerro Manakwatai
Mt. Roraima
Rio Yuruani
Rio Comik
Cerro Coimara
Arabopu
Aravaima
Cº Canaupang
Canaupang
Cº Sabana
Cº Erematura
Cº Varamatipu
Arekuna
Cerro Zuaptipu
Ronta
Mowaimata
Serra Tolimbarutipeur
Peli woi-uto
Cerro Caroima
Sª Mukuripa
Sª Yuruktipu
Sª Hormi
Serra Weitipu
Pauiputu
Cach Yamakak
Salto Muretauk
Kalubatk Fall
Wentmana Fall
Mt. Wokomung
Assakama Cr.
Mt. Morakabang
Serra Echarang
Serra Moratipu
Kamowta Raps.
Kamana Mt.
Waipa
Serra Yolang Paro
Serra Achinat
Iwaipai Mt.
Sª Maria
Kurikaberu
Sª Weira-ipin
Salto Orinduik
Sª Enamung
Makuxi
Enamung
Serras Serekong
Pacaraima
Rio Landmark
Rio Pipi
Rio Waialong
Rio Cauaraung
Rio Cotinga
Rio Aiba
Rio Mapari
Rio Cuquenam
Rio Arabopu
Rio Monokaveng
Rio Ekotbara
Rio Pasaruibo
Rio Tana Alpacha
Salto Moro-mota
Salto Rua-mota
Salto Orinedook
Salto Marei-mota
Pauiputu
Tumong Kanaru R.
Trong River
Sakabi R.
Kakapara R.
Rotaro R.
Wapary R.
Haiek R.
Pontl R.
Tukuri R.
Yaka R.
Tiara R.
Mong River
Kukue R.
Karumbaru R.
Kampapa R.
Wapara R.
Mong R.
Zambaduk R.
Atar River
Aru Paru R.
R. Kako
R. Kwtard
R. Waurpa
R. Curipan
R. Cauwaluk
R. Mapurak
R. Tupperbaing
R. Cotinga
R. Parari
R. Waitang
R. Maurthop
R. Maniek
R. Kai
Ig. Cotopaxi
Ig. Cape
Ig. Maurthop
Ig. Maniek
Ig. Chibu
Ig. Tolimbaru
Ig. Nabaru
Ig. Kamoba
Ig. Maroman
Ig. Kamoa
Ig. Horuktana
Paruima
Serra Cotinga
Parucampona

Mt RORAIMA REGION
Scale 1:525,000
10 5 0 10 Miles
20 15 10 5 0 10 20 Kilometers
Altitudes & form lines in meters
Mission stations
Settlements
Astronomical points
Boundary beacons
Tribal names Makuxi
ROUTES OF PRINCIPAL EXPLORERS
Robt & Richd Schomburgk, 1838 & 1842
C.B. Brown, 1869 & 1871
Boddam, Wetham, & Mc Turk, 1878
Whitely, 1883
E. im Thurn & Perkins, 1884
McConnell & Quelch, 1894 & 1898
Com. de Límites, 1900, 5, 10
Anderson, before 1908
Koch Grünberg, 1911
C. Clementi, 1915
G. Tate, 1927
Arekuna
Makuxi
Sokoriko
Taulipang
Uapixana
Serra Pacaraima
Rio Tacutu
Rio Surumu
Rio Cotinga
Rio Tavora
Rio Uraricoera
Rio Parima
Rio Mahu
Rio Maú
Rio Ireng
Rio Cuyuni
Rio Mazaruni
Rio Cuquenan
Rio Kukenaam
Rio Kamarang
Rio Potaro
Rio Essequibo
Rio Siparuni
Rio Rupununi
Rio Takutu
Rio Branco
Rio Negro
Rio Solimões
Rio Amazonas
Rio Içá
Rio Japurá
Rio Caquetá
Rio Putumayo
Rio Napo
Rio Tigre
Rio Pastaza
Rio Marañon
Rio Huallaga
Rio Ucayali
Rio Urubamba
Rio Madre de Dios
Rio Beni
Rio Mamoré
Rio Guaporé
Rio Paraguay
Rio Paraná
Rio Uruguay
Rio Iguassú
Rio Tietê
Rio Grande
Rio Doce
Rio Paraíba
Rio São Francisco
Rio Tocantins
Rio Xingú
Rio Tapajós
Rio Madeira
Rio Purús
Rio Juruá
Rio Javary
Rio Yapurá
Rio Içá
Rio Negro
Rio Branco
Rio Trombetas
Rio Nhamundá
Rio Jamundá
Rio Paru
Rio Jarí
Rio Maracá
Rio Oiapoque
Rio Araguary

TEHRAN AND THE ELBURZ

Frederick G. Clapp

A FIRST view of the magnificent Elburz Range, from whatever direction one approaches it, is inspiring. Any journey made parallel to it by motor or on muleback discloses hourly a fascinating array of diverse topographic forms. A geological excursion into the range at any point whatever throws light upon important scientific problems. Residence within sight of the range enables one to study its intricate peaks, valleys, and spurs under all conditions of light and climate. But a journey across the range is what reveals the Elburz as a vast mountain barrier scarcely equaled in the world for contrast in the conditions of life on the southern and northern slopes.

A visitor entering northern Persia by way of Baghdad, Kermanshah, and Hamadan finally finds himself in a broad valley, 3000 to 4000 feet above the ocean, bounded on the south by low ranges 5000 to 7000 feet in altitude which form a constant feature of the country from south of Kazvin as far east as Samnan. If the journey be made in the winter, a snow-filled pass between Hamadan and Kazvin may be difficult to cross, for doubtless the mountains will then be cloaked with snow even if the plateau surface be bare. But heavy snow sometimes falls at Kazvin and Tehran, and both of the highways which lead from the plateau cities to the northern side of the Elburz are at times likewise impassable. Patches of snow may be seen on the Elburz until midsummer, but even lofty Demavend, 18,700 feet, the center of the Range, may then become exposed to its summit, for the dry plateau air evaporates the snows rapidly.

As one passes through Kazvin he is likely to comment on the abundance of nut and fruit orchards for which that city is famous among Persians. Pomegranates and walnuts are among the staple products. As in many cities south of the Elburz, the Kazvin orchards and gardens receive no water in summer but depend solely on the winter and spring precipitation, reënforced for a few months of the year by water from the *kanats*, or artificial tunnels. After the spring months have passed, *kanat* water is generally in such demand for domestic uses that none can be spared for the orchards.

Some miles east of Kazvin a faint trail can be seen crossing the Elburz in the direction of Tunakabun—a garden district of the Caspian lowland. Farther east a branch motor road leads to some coal mines in the south edge of the mountains. Dilapidated villages are fre-

quent on the main highway; and the *chai-khanehs*, or tea houses, along this much traveled road are even more common.

Karaj is a prosperous village where the main highway crosses a river of the same name. This is a perennial stream from the heart of the Elburz, but it fans itself out 60 miles southeast on the edge of the Dasht-i-Kavir, or Great Salt Desert. Recently an ancient ditch has

FIG. 1—The Elburz Range seen from Tehran.

been reopened for the purpose of carrying water from above Karaj along the mountain base to Tehran, where water is greatly needed.

As Tehran is approached, mighty Mt. Demavend comes into sight; and, since the traveler generally arrives in the early evening, the peak may at times be observed in all its sunset glory, the last rays of the setting sun reflected from the white snow seeming to give the mountain a crown of gold. Coming from the west the traveler enters Tehran by the Kazvin Gate where, as in many places between Baghdad and Tehran, a police record is taken of every motor passenger.

GENERAL ASPECT OF TEHRAN

In the midst of the great plains lies Tehran—octagonal in shape—having fourteen gates, of which thirteen are elaborate blue-and-white tile structures surmounted by towers. Formerly a path enabled pedestrians to cross each of the gates in promenading on the city ramparts; but through general dilapidation the gates are now mostly impassable.

FIG. 2

FIG. 3

FIG. 2—A typical residence street of Tehran in winter. Mud walls, tree borders, and roadside ditch for domestic water supply.

FIG. 3—A garden in Tehran behind the mud walls of Figure 2.

The city wall, about twelve miles in length, consists of an ugly rampart or embankment of gravel, bounded on the outside by an ancient moat or ditch, nearly 100 feet wide and 50 feet deep, crossed at each gate by substantial masonry bridges built in order to carry Tehran's principal tributary streets to the country and indicating that water once flowed in the moat or even now flows in it from time to time. Though the moat was dry during the entire eleven months of the writer's visit, persons now living there have seen it full of water.

The interior of Tehran has been often described—its central square (Maidan-i-Topkhaneh), which formerly contained a large pond and is surrounded by the Imperial Bank of Persia, the telegraph offices, police headquarters, and municipal buildings; the famous parade ground not far to the west; the Khiabani Ala-ed Douleh (a main avenue leading north from the Maidan); the old palace containing many interesting antiques, hemmed in by ugly office buildings, abandoned *anderuns*, and cheap shops; typical oriental bazaars which aggregate miles in length; in addition to which are the magnificent wooded grounds of the British and Russian Legations some distance from the center of the city and the beautiful, even if less elaborate, American Legation park outside the ramparts. Khiabani Lalezar, or the principal shopping street of the foreigners, might also be mentioned, as well as the neat brick building occupied by the Medjless (Parliament), the narrow-gauge horse tramways which serve several parts of the city, numerous motor bus lines, beautiful gardens (overemphasized in all descriptions of Persian cities) hidden away behind mud walls, the houses of the Shah and other notables. But the subject of architecture is outside the scope of the present article.

Suburbs of Tehran

In a country where the population is scant, a city of over 200,000 has few large suburbs. Thus the nearest competing municipalities are Kazvin, 90 miles to the west, and Kum, 75 miles south, while to the east there is no fair-sized city until Samnan is reached, 110 miles due east or 150 miles by the highway leading to Meshed.

The most important suburb of Tehran is doubtless its principal religious cynosure—Shahabdulazim—situated seven miles south, whose beautiful blue mosque dome is visible from many miles in all directions. Shahabdulazim is the resort of a large proportion of the population on Fridays and feast days, and the narrow-gauge railway leading to it from inside the south gate of Tehran is crowded on such days, as is also the good macadam highway. Founded on the ruins of Rei (Rhey or Rhages), walls of which are still conspicuous, and occupying the center of a rich alluvial district not far from the center

of the great Tehran Valley, Shahabdulazim has much to attract religious devotees and others.

Other important villages exist: Karaj, already referred to, situated at the point where the main Kazvin road crosses the river of that name; and Kand, lying eight miles northwest of Tehran at the

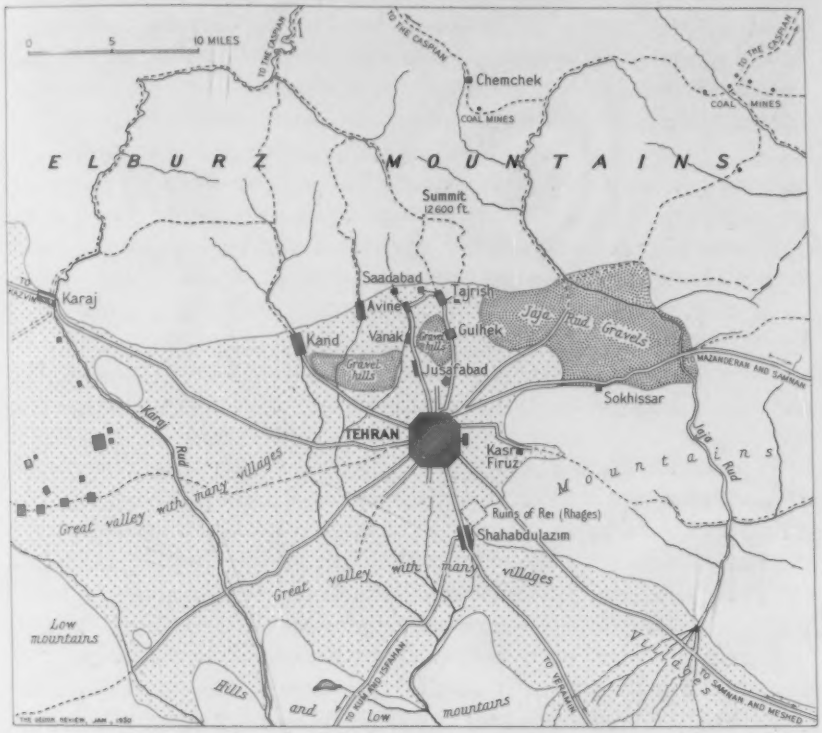


FIG. 4—Sketch map of the environs of Tehran. Compare Figure 11.

entrance to a deep mountain valley. The plains surrounding Tehran are dotted with numerous smaller villages, especially to the southwest, where a village exists to about every square mile of country throughout an area of perhaps 250 square miles extending to the base of the southwestern mountains.

The residence preferred as a summer resort is the high altitude district of Chimron, in which Gulhek, Tajrish, and other large villages are situated. All of the population who can afford to do so spend their summers in Chimron which, resting on the gravel fans near their upper or mountain extremity at an altitude of over 5000 feet, has an agreeable summer temperature. In the winter, however, Chimron may have a heavy snowfall, and few city people go there.

The Gravel Fans

The newcomer cannot fail to be impressed by the extent of the vast gravel outwash fans that constitute the plain on which Tehran lies. The gravel deposits resemble a single continuous plane surface, without appreciable topographic relief except its impressive upward parabolic sweep towards the Elburz. In approaching Chimron, however, one discovers that the gravel topography does not form a unit but is composed of various commingling fans debouching and sloping outwards from gulches in which enormous boulders are more and more frequently found as the mountains are approached.

From the main Chimron road a gently rising gravel mass lying to the west, on which the Military Hospital and the village of Jusafabad are situated, furnishes an example of a fan formed at a level higher than usual by outwash from a comparatively large mountain gulch which extends several miles into the mountains. This fan is visible from afar, rising towards the Elburz with a fairly regular grade up which ascends a good motor road.

In continuing north on the main Chimron road one passes through isolated hills of gravel rising several hundred feet above the general level and in their topography resembling glacial moraines. The writer has seen one geological map on which these deposits are represented as of Neocene age, but on careful study they appear to be merely the remains of a series of gravels that must have been formed in the Pleistocene or Recent epoch and of the same origin as the later fans which are more unified topographically.

Behind these hills of early gravels—differing in no important lithologic respect from the fans now being deposited—are a number of picturesque villages, such as Tajrish and Saadabad. The last-mentioned is the site of the summer palace of the Shah to which a grand boulevard is being constructed by the government. In these protected valleys and in flat lands which have resulted from local silting and even on the open slopes of the gravel itself a moderate amount of wheat is grown by means of irrigation.

In the vicinity of Tehran alluvial fans are also notable in a small reëntrant valley, at Kasr Firuz four miles directly east of the city, where a typical and impressive fan fills the entire valley to a width of about a mile, ascending rapidly eastward into the mountains. Twelve miles south of Tehran there is a point in the great valley where its elevation is less than 3000 feet above sea level, from which the valley rises to the south, and thence southward one travels on an entirely different series of fans. There are fans and fans, and we gradually come to realize that the formation here is a normal one, occurring on a vast scale, repeated in all Quaternary and late Tertiary valleys

that existed, so that it may often be difficult to determine which are the original Tertiary deposits and which are redeposited.

The Jajarud Gravels

The most important gravel upland topographically is that of the Jajarud gravels. These can be seen from the ramparts of Tehran or by looking east from almost any point on the Chimron road. They appear to be a rather flat-topped deposit of great extent standing at an altitude of perhaps 6000 feet at the north end and extending along the eastern sky line from the Elburz seven miles south to the eastern mountains, having the usual fanlike slope southward. The contrast in elevation and configuration between this gently sloping gravel formation and the rugged bounding Elburz and eastern mountains stamps the deposit as a gravel formation even from a distance.

The best point from which to appreciate the relations of the respective topographic types is, however, on the Mazanderan road about three miles east of Tehran. The Jajarud gravels visibly descend west and south from a point in the northeast where the Jaja Rud emerges from the Elburz. A faint road furnishes a route for practicable but poor motor transportation as far as the summit of the gravels, within two or three miles of the Jaja Rud, narrowing to a mule trail and descending the northeast slope of the gravel mass in order to reach the river. This is the trail used to bring bituminous coal to Tehran from the mines at Shemsek, and it constitutes the route along which the Persian Government contemplates having an overhead tramway constructed by a German firm.

Where the Jaja Rud emerges from the mountains its elevation is not far from 5000 feet above sea level, or over 1000 feet higher than Tehran. A proposed plan to bring water from the Jaja Rud to the Tehran plain by tunneling these gravels may be practicable, but the project will work a hardship on the farmers and communities of the Veramin plain who are dependent on the distributed river water. North and south of the point where the main highway crosses the Jaja Rud the gravels of the same series are exposed in cliffs that are in places 100 feet high. This topography indicates that in past time the Jaja Rud may have flowed west by way of the Tehran plain and that the present narrow valley to the south has been recently carved by the river owing to the torrential damming caused by the vast mass of rock débris brought from the mountains and dropped at the entrance to the ancient broader Tehran plain.

It might be supposed that the Jajarud gravels are no different in composition from other gravels deposited as outwash fans near the mountain base. It is true that the derivation and processes of accumulation of the gravels are almost identical. Yet there is a difference

FIG. 5

FIG. 6

FIG. 7

FIG. 5—Looking across the Jaja Rud Valley at upland of Jajarud gravels, due east of Tehran.

FIG. 6—A rocky valley at Tajrish north of Tehran, showing torrent-deposited character of gravels near their source.

FIG. 7—Ruins of the Kizil Alan (Red Wall or Alexander's Wall) between Gumesh-tepeh and Gumbad-i-Kabus, 336–323 B. C., reconstructed A. D. 530–578.

FIG. 8

FIG. 9

FIG. 10

FIG. 8—Elburz Range from the American School, in winter, showing typical outlying village and rising gravel plains.

FIG. 9—Karaj River and Karaj a few miles west of Tehran.

FIG. 10—Military Hospital and gravel plains, from three miles north of Tehran, showing *kanat* in foreground.

in composition, for the Jajarud gravels originated at a more remote distance in the Elburz than did the other Tehran fans east of the Karaj Valley, as shown by the discovery of abundant pebbles of Devonian age in the Jajarud gravels. Devonian rocks are not a component part of any gravels found farther west, but the parent outcrops are known to exist in the Jaja Rud Valley five to ten miles north in the Elburz.

Underground Watercourses, or Kanats

A discussion of the highland valley terranes of Persia brings us naturally to a geographic type that is entirely artificial—that of the *kanats*.[1] The *kanats* are small tunnels, miles in length and only two or three feet in diameter, dug by manual labor scores or in some cases hundreds of feet below the surface of the gravels, through which water is distributed to portions of the valleys far distant from the mountain bases. All cities in the barren portions of the Persian plateau are watered by *kanats*, which also supply large areas for agricultural irrigation. Thus Tehran is served by water almost entirely by means of the *kanats*, which extend outward from the base of the Elburz, passing through village after village, reaching the gravel surface in places, again descending to depths, some of them appearing at the surface at the northern edge of the city, where they cross or pass by tunnel underneath the moat and the rampart. Every street running in a north-south direction is provided with a surface or subsurface water channel, and if a pedestrian is not careful on a dark night he is likely to stumble into a hole leading to one of the concealed ditches.

The ancient *kanats* were formerly under private ownership. Lately, however, the municipality has taken charge of them and distributes all water more or less equitably by opening gates (generally in the primitive manner of digging away a heap of obstructing gravel or earth) leading into the respective gardens or *ambars* (storage tanks) once in eight days on an average. The householder is therefore obliged to store enough water in the *ambars* to last until his next turn comes to have the water admitted.

The price of water is assessed on the householder by the municipality. All of Tehran's renowned gardens are supplied by *kanats;* the inhabitants use the water for all drinking and domestic purposes; but drainage passes off by means of the same *kanats*, which continue their courses from house to house and square to square as far as the south rampart of the city, beyond which they may continue into the country, watering valuable farm lands.

The discriminating European residents purchase their drinking water from the British Legation, which maintains its own *kanat*, and

[1] C. B. Fisher: Irrigation Systems of Persia, *Geogr. Rev.*, Vol. 18, 1928, pp. 302–306.

water from this *kanat* is boiled by the ultrafastidious as an added precaution. The old channel, reopened to bring water from the Karaj Rud, constitutes only a "drop in the bucket" of what Tehran needs in order to continue its growth and prosperity. In a good year, when there has been a winter snowfall on the mountains and some spring rains, everything is normal; but during every dry year there is great suffering, and three successive dry years produce famine conditions in this part of Persia.

FIG. 11—Sketch map of northern Persia showing the author's routes, 1927–1928. Scale 1:5,000,000.

DEPARTURE FROM TEHRAN

In the early morning we depart from Tehran via the Chimron Gate for Mazanderan, although, strange to say, the gate of this name is not the one that leads to the villages in the district of Chimron. That one is called the Doulat Gate. Mt. Demavend, forty miles away to the northeast, now rears its summit in all its majesty high above the rest of the Elburz. The main mountain range sweeps across the northern sky; and a few masses of green trees which shelter Gulhek, Tajrish, and other summer resorts outlined against the mountain slope form a conspicuous contrast to the barren gravel plain and the more barren rocky mountains. Such villages can be reached by a broad, tree-lined macadam road which is encumbered in the summer rush hours by a stream of automobiles, omnibuses, and trucks, for the greater part of Tehran's well-to-do classes spend their summers in the country.

Between Tehran and the Elburz a belt of low foothills rises several hundred feet above the present-day gravel fans. These hills are composed of somewhat more ancient gravels that stand amidst the more recent apron deposits. Behind the isolated hills a few prosperous villages are situated, and small crops of wheat and other grains are

raised in an average year by means of irrigation. Orchards and gardens are common in these villages, and one may get the impression that plenty of irrigation water exists. This, however, is not the case over large areas, for the great landowners, influential politicians, and dwellers on the north side of Tehran live in comparative comfort whilst their countrymen to the south may be suffering from drought.

Many picturesque villages nestle in remote valleys in the high Elburz, and a number of trails cross the range from Tehran to the intermontane valleys and the Caspian coast. Ancient domains of royalty abound, and one is told of fine old ruins that can be found by searching. There are also some features of milder interest, such as waterfalls and hunting and fishing grounds. But as a whole the mountains, except to a geologist, are barren and uninviting. The south flanks and central portions of the Elburz crests consist largely of a much folded and eroded series of volcanic tuffs, agglomerates, and interstratified lavas, which are believed to aggregate two to three miles in thickness. For convenience these beds are called the "green series" among the geologists who have studied them, for the predominant color is green, although the beds are interstratified with reds and whites which are characteristic of tufaceous series the world over. Basaltic lavas are also interstratified with these ash beds, generally standing out in dense black; thus the series is one of contrasts when seen from a distance. The "green series" is early Tertiary. Within a few miles of Tehran the older rocks—Carboniferous and Jurassic—are involved in the Elburz folding, while far to the west and east the Miocene sediments are also folded into the same magnificent structures. In some places Mesozoic and Paleozoic rocks are exposed in the midst of the Tertiaries, and a few mineral deposits are rather vaguely reported.

A mediocre quality of coal is found in considerable quantities throughout an area lying west from the vicinity of Mt. Demavend to a point nearly north of Tehran, and this coal is mined and sold in the city for eight tomans per *havar* (about $24 per ton). But in general the Elburz is devoid of great human interest and of important minerals. Its main geographical function seems to be that of a barrier, tempering the winter climate and protecting the plateau cities from cold northern winds; and in former times it has protected the country from the barbarous hordes of central Asia. The oft-repeated raids of Turkomans, Turanians, Tatars, and other peoples show that some barrier was needed.

The Road to Firuz Kuh Pass

A few picturesque settlements are seen on the main highway, but they are widely spaced, for the plateau country has not a large popula-

tion. One of the principal villages is Demavend, situated three miles off the main highway and 12 miles south of the mountain of the same name. At Aineversan a small stream, led to the edge of a frowning mountain by an irrigation ditch, plunges down through a rocky channel for a distance of 900 feet vertically to the village and highway level. Not far from here a good-sized lake is reported at an altitude of somewhere near 9000 feet and three miles distant in the mountains.

Soon after noon the traveler finds himself in the village of Firuzkuh. The same name is applied to the principal mountain range directly to the north and also to the pass over which the highway leads to Mazanderan. From near Firuzkuh the writer made a side trip to Samnan, five hours distant by automobile, and in so doing he was obliged to cross a mountain pass at a barometric altitude of about 8500 feet—one of the highest in Persia and higher than the main pass on the Mazanderan road.

The pass of Firuz Kuh has an altitude of over 7000 feet. Like that which crosses the Elburz northwest of Kazvin it is reached by so slight a grade that one does not realize the nearness of a divide until the road breaks off suddenly to descend the north slope. Then the tuffs and lavas are left behind, and Paleozoics and Mesozoics form the country rocks.

FIG. 12

FIG. 13

FIG. 14

FIG. 12—Doshantepe Gate, Tehran, showing nature of rampart and ancient moat.

FIG. 13—Doulat Gate, leading to the north of Tehran, showing the old moat.

FIG. 14—The tomb of King Kabus, a tenth-century monument at Gumbad-i-kabus.

Soon forests make their appearance, and the traveler is in Mazanderan. At the same time he finds himself surrounded by rugged scenery and descending towards the Caspian.

The Elburz As a Physical Barrier

As already explained, the Elburz is impressive in its topography. A traveler from Baghdad first appreciates its immensity near Kazvin, where the roads from Tabriz, Baghdad, and Rasht converge into the much traveled highway to Tehran. Everywhere, as one travels eastward, the range is either visible within a few miles to the north or it skirts the road, as the case may be. It is broken by innumerable gorges; but, east of the Safid Rud near Rasht, it has no gap deep enough to permit a stream to cut entirely across the range. The Karaj and Jaja rivers are the largest streams flowing south from the Elburz, while the north slopes are drained by numerous rivers and rivulets.

The Elburz Range is nowhere easily scaled. The highest summit behind Tehran is 12,600 feet in altitude and requires a day for the ascent and descent from the Chimron villages. The summit of Mt. Demavend can be easily reached only during the summer months, by a round trip of at least three days from Demavend village. The trip from the village to the mountain top by mule and on foot is a difficult one but is occasionally made by Europeans and Americans. The ascent may have lost some of its fascination since the Junkers Company established a holiday airplane service to and around the peak.

The passable gorges across the Elburz are few in number. The only highways crossing the range are the Gilan road at a point 25 miles, more or less, northwest of Kazvin and the Mazanderan road over Firuz Kuh. Between these points lies an untraveled sequence of mountains throughout a distance of 180 miles, and east of the Firuz Kuh Pass no place exists where the Elburz can be crossed by automobile or wagon.

To be sure, a few mule and donkey trails are seen winding up the steep mountain slopes, and some of these may be passable for camels also. They furnish means for transporting the delicious fruits of Mazanderan to the plateau near Tehran and of various commodities in the reverse direction; but, since the needs of the people remain few, freight is not heavy. A week is generally necessary to traverse any of these trails to the Caspian coast.

The entire plateau of Iran which lies south of the Elburz Range has been elevated to minimum heights of 3000 to 5000 feet above sea level, forming one of the great uplifted land masses in the world. The range, or more explicitly, the complex of mountain ranges making up

the Elburz, rises to altitudes of 10,000 to 12,000 feet, with the volcanic Demavend reaching 18,700 feet. The rocks have been folded and faulted to an amazing extent. Since the Caspian coast descends to 84 feet below ocean level, the difference in altitude between the north and south sides of the mountains is very great.

In the matter of climate the change from the south to the north side of the Elburz is remarkable. The plateau of Iran is substantially arid; and in fact vast deserts, both of the sandy and salty types, lie in the plateau within a few score miles of the Elburz. The rainfall at Tehran appears to be less than ten inches a year, but the figures are a matter of guess, for exact weather records have seldom if ever been kept in Persia. As one reaches the north side of the mountains, the climate changes abruptly from dry to moist. The writer recalls the contrast effectively seen on a journey via the Firuz Kuh Pass. The plateau sky was cloudless as it had been for two months. On starting down the steep descent through a rocky gorge on the north flank, a billowy mass of white was seen thousands of feet beneath in the far distance. It resembled a stormy sea. It was a sea of cloud, and the sunny skies of Iran were being left behind. Within an hour the clouds had been entered, and the sky had changed in color from deep blue to ashen gray; in another hour rain was falling—the first rain seen in some months. The rainfall in Mazanderan and Gilan provinces is heavy.

Change from Desert to Forest

In the plateau country south of the Elburz the only trees are situated in the villages and in cultivated gardens or parks that surround them. Outside Tehran and the other plateau communities the country consists of a barren yellowish-gray waste of gravel. In the less gravelly portions water is distributed for agricultural purposes, as has been said, through the *kanats*. Thus the plateau as a whole raises a large amount of grain; fruits and vegetables are found in the village gardens; and under average climatic conditions there is sufficient food to support the life of the existing population.

After passing the divide, however, all is changed—trees quickly make their appearance and become dense and tall as the lower slopes of the mountains are approached. On reaching the foothills, one is in a country where tigers, bears, leopards, and wild pigs abound in a jungle. The country is cloaked with a mass of green from the Elburz summits to the Caspian coast. The plain, from a mile to 40 miles in width, that fringes the Caspian is extensively cultivated—the staple crop being rice.

The desert region to the south of the Elburz is dry, cold in winter and parched by heat in summer. The moist lowland to the north has winters that are seldom too cold for ripening oranges and other

citrus fruits, and the summers are called "semitropical." Mosquitoes, flies, and other insect pests are an ever-present plague during the warm months. Although rain is distributed throughout many months of the year, it falls most continuously in winter, during which the plains are impassable for automobiles even on the main road to Asterabad, although this condition is being gradually remedied.

As the writer painfully jogged along on muleback or floundered on foot through water-soaked trails that lead into the Elburz from villages in the northern plains during the last days of 1927 he forcibly realized the help that will come to Persia through the building of highways and railroads. American engineers in the employ of the Persian government have surveyed a line of railroad over the Elburz from Bandar-i-Gaz on the Caspian coast; the line was graded by them as far as Ashraf, and the work is being continued by a German syndicate. Tehran and Kazvin on the south of the mountains and Barfarush, Asterabad, and Rasht on the north are cities of considerable size in which many of the population have acquired wealth and learning. No Europeans or Americans are found aside from those in Tehran, a few in Rasht, and a sprinkling of Russians in Rasht, Pahlevi (formerly Enzeli), Barfarush, and Bandar-i-Gaz.

Large towns are numerous in Masanderan, but cities are few. Ashraf, site of an ancient palace, Sari near the mouth of the Tajan Rud, Barfarush, seat of the provincial government, and Amul are the principal cities of the province. Judging by the solidly built structures in Barfarush, many of which bear Russian names, this city has housed many Russian business men in past decades, and Bandar-i-Gaz still has a fair number of Russian merchants. Karasu, in Asterabad Province, is an abandoned port at the southeastern angle of the Caspian Sea, the well constructed buildings of which indicate that a substantial Russian fishing industry existed within recent years. But when the writer was there a half dozen Persian police constituted the entire population.

There is, also, a cultural difference between the two sides of the Elburz, though it may be rather intangible to the foreigner. The Tehranis call the Mazanderanis "savages," and the mode of life of the last-mentioned is certainly not as civilized as it is in the cities of the plateau, though even there it is sadly deficient in what might be called the comforts and luxuries of ordinary existence. Most of the coastal towns carry in stock few foreign goods of any description, and no motor roads exist except the one from Tehran to Asterabad, another from Tehran to Pahlevi, and short dry-weather branches. The natives living east of central Gilan Province use few modern articles. Thus we might say the generally recognized criteria of culture are absent. As to education, there is almost none, north or south, outside of the larger cities.

The cultural difference may be reflected by the differences in food, for the northerners eat largely rice while the plateau population lives on bread and some meat. The excellent oranges of Ashraf, Tunakabun, and other districts in the coast country are shipped by mule or donkey as far south as Tehran, but they are expensive or not obtainable elsewhere on the plateau. Tea culture has been successfully tried at Lahijan (east of Rasht), and silk is raised elsewhere in Gilan. Cotton is grown abundantly in some parts of the north, and modern cotton gins have been seen in a few places near Barfarush. But the coastal districts outside of Pahlevi and Rasht seem largely not to appreciate the wonderful sustenance available in the fine fish of the Caspian waters, although the new treaty with Russia now gives Persians the right to fish there. The fine forests are being cut locally but, in the absence of a foreign forestry adviser (the one recently discharged had done good work), are not wisely administered and will be soon stripped unless cutting be properly regulated. If the north country contains petroleum that fact is yet to be demonstrated to the world, as few explorations have been made for it and no drilling has been done. However, the Caspian coast surely has possibilities of development along many lines.

BURMA: AN UNDEVELOPED MONSOON COUNTRY

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IN many respects Burma is an anomaly. Geographically an integral part of Indo-China, politically it is one of the major provinces in British India. Yet the contrast between Burma and the remainder of India is such that one tends instinctively to consider "India" as excluding Burma unless that province is specifically mentioned. In common with most of Indo-China, Burma remains at the present day a markedly underpopulated country, thus contrasting with the densely peopled lands of India on the one hand and China on the other. This low density of population is due to the geographical isolation of the country, certainly not to lack of natural resources. Surrounded by a wall of mountains, Burma even at the present day remains unconnected with the rest of India or with any of her neighbors by either railway or metaled road; and, unless one is willing to spend weary days and nights trekking along mountain tracks in ten- or fifteen-mile daily stages, the only access is by sea. Even so Burma lies rather off the main lines of world trade. Modern steamers from the Far East to Europe, like the medieval traders of old, go direct from Malaya to Ceylon, leaving Burma on the north; the steamers which serve Bombay, Madras, and Calcutta rarely come on to Rangoon. On the other hand Rangoon is likely to become an essential air port on routes between Europe and Australia or the Far East.

Ethnologically as well as structurally Burma is linked with Indo-China and China rather than with India. All the native inhabitants are Mongolian: their affinities in race, language, and customs are with their neighbors to the east. Indeed the connection is so close that the Shans of Burma and the Siamese are identical. Although Rangoon, like all great ports, is cosmopolitan and, indeed, mainly populated by immigrant Indians, there are few world travelers who fail to appreciate the contrast when arriving from India. Coming from Calcutta to Rangoon not only is one struck by the mongolian features of the Burmans, but one sees for the first time that *sine qua non* of all Far Eastern towns—the immigrant Chinese.

As a result of its geographical isolation, Burma occupies the interesting position of being one of the "new lands" of the tropics. The development of the new lands of temperate regions has everywhere attracted the attention of geographers; but Burma, as an outstanding

example of a new land of the tropics being developed by tropical peoples, has scarcely been considered. It comes as a surprise to learn that Rangoon, in many years recently, has held the world's record as an immigration port. Upcountry one is struck by the immense areas of cultivable land which remain waste for want of cultivators.

FIG. 1—Aerial view over part of Rangoon Harbor.

The mighty Chindwin and Irrawaddy are still the great highways of the country, for their water has not yet been requisitioned for irrigation. No motor road yet penetrates even to Mandalay, no railway yet reaches those great oil fields of Burma—Yenangyaung and Singu.

The Province of Burma,[1] as constituted since the annexation of Upper Burma in 1886, comprises the British Territory of Upper and Lower Burma, the extensive native states known as the Federated

[1] The Survey of India publishes maps on the scale of 1 mile, 2 miles, 4 miles, 15 miles, and 32 miles (one sheet) to the inch, as well as detailed maps of forests. There are two series of 1-inch maps, an older series in double sheets and a newer series (colored) in sheets measuring 15 inches each way. The ¼-inch maps are in degree sheets. Most of the country has been mapped; and 1-inch and ¼-inch maps are obtainable for the greater part of the country. Various geological maps are published in the Records and Memoirs of the Geological Survey of India; and manuscript maps on the scale of 1 inch to the mile have been made of considerable areas and will be copied and supplied at cost by the Geological Survey, Calcutta.

FIG. 2—Map of Burma showing relief. Compare Figures 3 and 4.

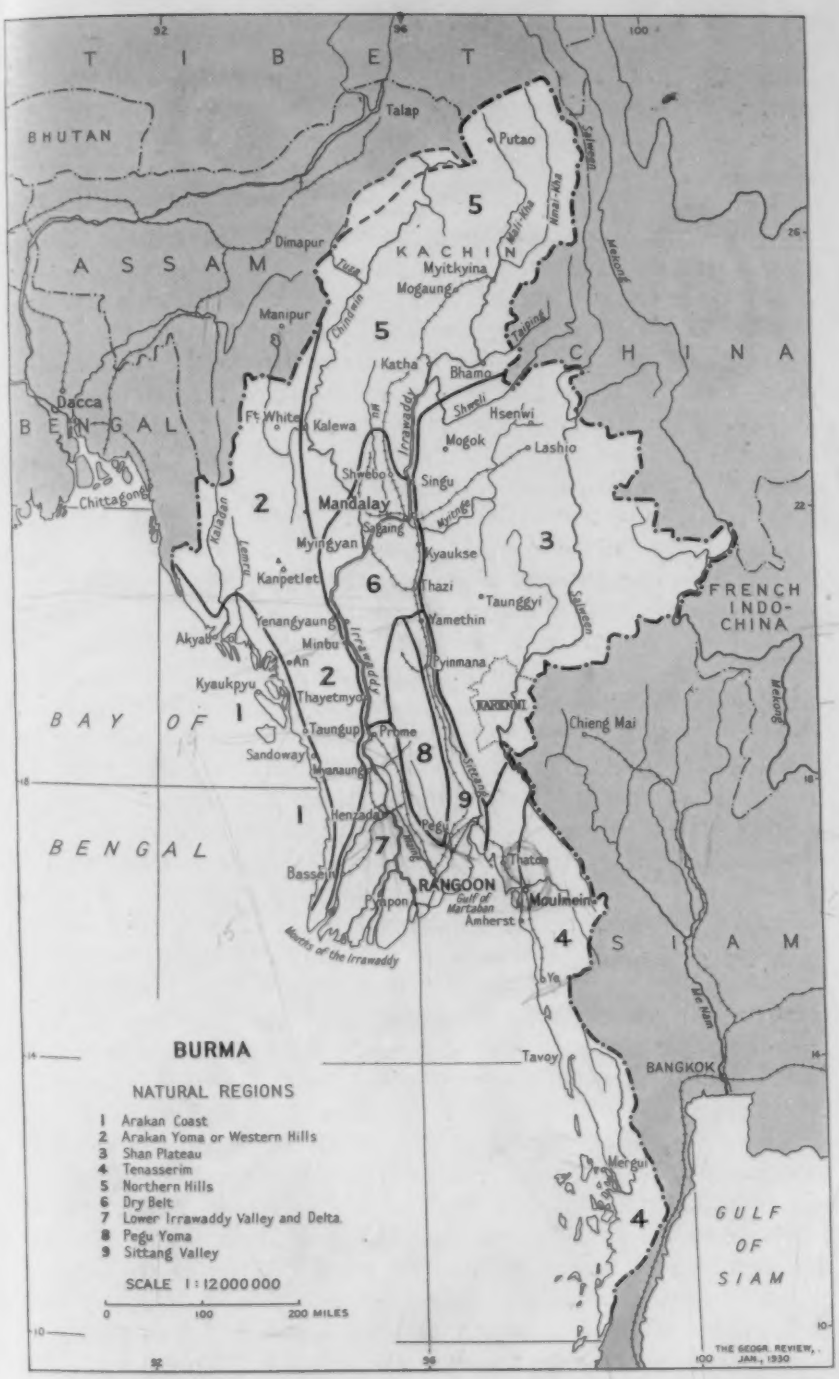

FIG. 3—Map of Burma showing natural regions and railways. Note the isolation of the country.

Shan States, and Karenni, as well as several tracts of unadministered territory in the more remote parts.

Natural Regions

Considerations of relief, structure, and climate permit the division of this territory into a number of natural regions. Several of these are clearly marked and can be readily appreciated when one is traveling in the country, especially by changes in vegetation.

In many cases the dividing lines between natural regions can be accurately drawn: for example, on each side of the Sittang Valley the forested hills commence quite abruptly and the agricultural lands and villages end with equal abruptness. In the same way, there is no doubt as to the limits between the Irrawaddy Valley and the forested Pegu Yoma, and often the limit between the Irrawaddy Valley and the foothills of the Arakan Yoma is defined with equal clearness.

On the other hand it is particularly difficult to get any exact statistics on the basis of natural regions. Burma is divided into about half a dozen divisions, each of which comprises several districts. The district is the smallest unit for which statistics of classification of area, agricultural crops, forests, population, etc. are usually available. But, unfortunately for the geographer, very few of the districts lie in a single natural region. They are usually purposely arranged so as to include fragments of very different types of country. Thus the government official, known as the Deputy Commissioner, who is in charge of the Thayetmyo district has under his control a broad section of the agricultural lands of the Irrawaddy Valley, together with the forested and almost uninhabited foothills of the Arakan Yoma on the west, and of the valuable forests of the Pegu Yoma on the east. Similarly most other districts include tracts of agricultural and closely settled country as well as very sparsely populated forest areas. The statistical details, therefore, given in the sections that follow are based on published returns interpreted in the light of the writer's personal experience of nearly all parts of the country.

The general geology of Burma is relatively simple and controls topography to such a marked extent that the natural geographical and geological units in the country closely correspond. Four major physical divisions may be distinguished: the eastern massif of old rocks, the western fold ranges, the central basin (Tertiary), the Arakan lowland (Tertiary). On the basis of climate it is necessary further to subdivide the great central basin and to distinguish between the Shan Plateau and its southward continuation in Tenasserim. This gives the following nine regions, regions 5–9 being subdivisions of the great central basin: (1) the Arakan Coastal Strip; (2) the Arakan Yoma Chain, or Western Hills Region; (3) the Shan Plateau; (4)

Tenasserim; (5) the Northern Hills Region, or Wet Zone of Upper Burma; (6) the Dry Belt; (7) the Lower Irrawaddy Valley; (8) the Pegu Yoma; (9) the Sittang Valley.

The Arakan Coastal Strip

The Arakan coast is of the Pacific type, and the folded foothills of the Arakan Yoma approach closely to the Bay of Bengal in many

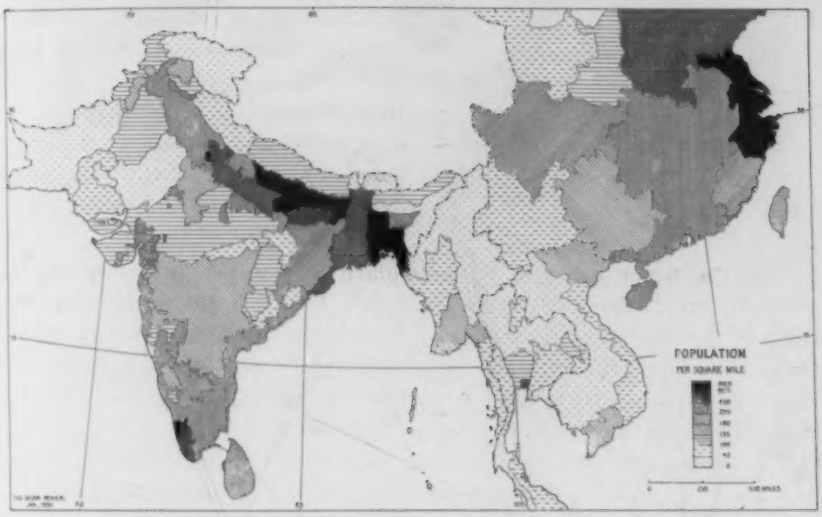

Fig. 4—Map of population density of southeastern Asia showing the comparative sparseness of population in the Indochinese peninsula.

areas. The actual coastal strip, therefore, may be said to comprise those areas which are sufficiently level to permit of settlement and agricultural development but which are both small and scattered, though including a considerable and important tract of alluvium in the hinterland of Akyab, and also a number of large islands such as Ramree Island. A glance at a map will show that the Arakan coast is very much broken up, both by rocky headlands and islands and by stretches of mangrove swamps. As a result harbors are numerous, but the mountainous country of the hinterland and the difficulty of communication across the Arakan Yoma have prevented the development of any considerable ports, with the single exception of Akyab.

The whole of the Arakan coastal strip enjoys a heavy rainfall, everywhere more than 80 inches per annum; and in many areas the rainfall may be truly described as excessive. Akyab has 196 inches, Sandoway 210 inches, and Kyaukpyu 175 inches, so that soil erosion by heavy downpours is much to be feared. The bulk of the population and of the cultivated land is found in the north of the region in the plains already mentioned as lying behind Akyab. By far the most

important crop is rice, occupying over 90 per cent of the whole area. The sea provides a second great product of Arakan, namely fish.

The principal town and port is Akyab, and it will be noticed that two navigable rivers provide highways into the interior—the Kaladan River towards the north, and the Lemru River towards the east. The other "towns" of the coastal strip are actually mere villages. Prospects for settlement and development are perhaps less promising in this part of Burma than in certain others, though there is a large amount of waste land which could be cultivated; but almost the only crop suitable for this very wet region is rice.

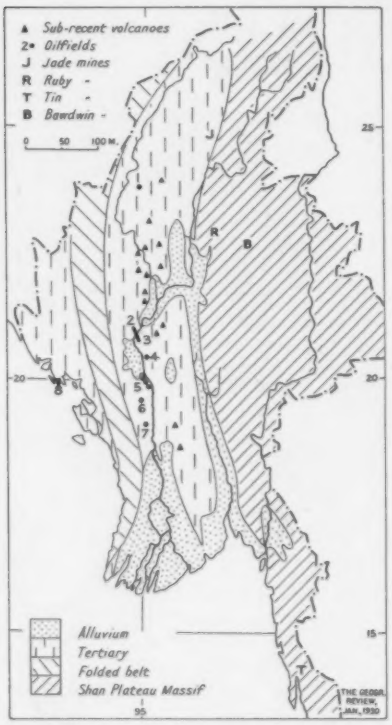

FIG. 5—Structural and mineral map of Burma. Numbers refer to oil fields: 1, Indaw; 2, Yenangyat; 3, Singu (38.3 per cent of Burma's total in 1927); 4, Yenangyaung (58.3 per cent); 5, Minbu; 6, Yenanma; 7, Padaukbin; 8, Arakan. The Bawdwin mines are mainly silver-lead mines but have also a large output of zinc and copper and iron ore is mined near.

As the geographical situation would suggest, the population of Arakan is distinct in many ways from that of the remainder of Burma. The Arakanese, although ethnologically closely allied to the Burmese, pride themselves on being different and on speaking a dialect which varies considerably from Burmese as spoken in the central tracts. It is not surprising also to find a fairly large population of Indians, especially Chittagongians who have spread southwards along the coast from the Chittagong regions and Bengal; but the total population of the whole natural region is less than 900,000 (census of 1921).

THE WESTERN HILLS REGION

Physically the Western Hills region consists of a very complex series of ridges, mostly with a north-and-south alignment, which consist of highly folded sedimentary rocks. But the whole area is thickly masked by its forest cover; and, broadly speaking, forests spread from the base of the foothills on either side to the summit of the highest peaks. On the wetter, western side the normal evergreen forest of the lower slopes has been largely replaced by the almost useless bamboo brake, and in this area the well known creeping bamboo

(*Melocanna bambusoides*) has obtained a strangle hold and is waging a successful war even against established forests.[2]

On the drier eastern side the foothills and lower slopes are clothed with valuable teak forests which give place at an elevation of about 3000 feet to the evergreen oak forests and then at greater elevations to pine forests; whilst here and there, on the highest tracts of all, rhododendron forests may be found. When seen from the Irrawaddy Valley, the Arakan Yoma presents the rugged outline of a rocky mountain range; but actually its curves are all rounded, and its highest

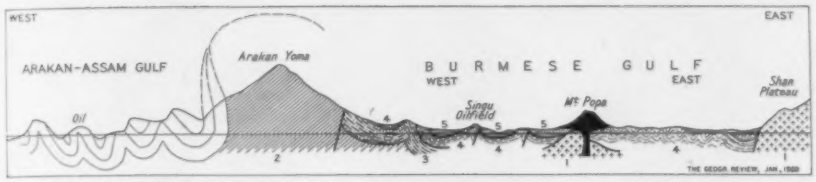

FIG. 6—Section across Burma from west to east. 1, old metamorphic rocks; 2, highly folded pre-Tertiary rocks; 3, Eocene; 4, Peguan (Oligo-Miocene); 5, Irrawaddian (Mio-Pliocene); black, volcanic.

points can scarcely be described as peaks. A good example of this is found in ascending to the summit of Mt. Victoria (10,085 feet): it is difficult to know when one has actually reached the top which, like the slopes, is thickly clothed with forest. It must not be inferred from this that communications in the hill region are easy. The mountain paths often climb several thousand feet only to drop two or three thousand feet for the purpose of crossing a narrow valley, and it is difficult to travel more than ten or possibly fifteen miles a day.

It is not surprising to find the hills region inhabited almost entirely by hill tribes—especially different types of Chins—and the isolation caused by difficulties of communication is exemplified by the variety of dialects spoken. It is often impossible for Chin living in one village to comprehend the speech of Chin living in a neighboring valley. The hill region is very sparsely populated; the villages are small, usually situated on spurs near a spring in the hillside, but well placed in case of attack. A village containing 30 or 40 huts may be considered as large. Life is difficult in the hills; the poor crops are principally maize, millet, and, in some cases, red rice, and are grown in those areas of shifting cultivation known as *taungyas*. The appallingly wasteful system of burning down the forest and using the land so cleared for two or three years at the most and then deserting it for fresh areas has been responsible for the destruction of vast amounts of valuable timber.

Passes across the hills region are few; the following is a list of the more important:

[2] L. Dudley Stamp: The Vegetation of Burma from an Ecological Standpoint, Calcutta, 1925.

1. The Taungup Pass is followed by a cart road from Prome on the Irrawaddy to Taungup near the Arakan coast; the really adventurous may attempt to do the crossing in a Ford car.

2. An Pass leads from Minbu on the Irrawaddy to An in Arakan and is a route similar in character to the preceding.

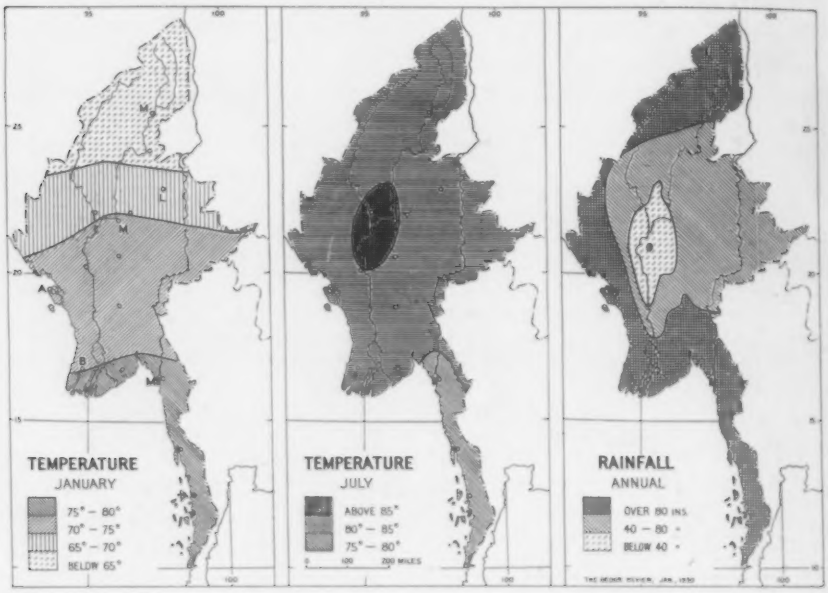

FIG. 7—Map of Burma showing January and July temperatures and annual rainfall. The stations shown in Figure 8 are indicated by initial letters (compare Figure 3).

3. The Yaw Chaung Gap leads from the Irrawaddy Valley into the settlement in the hills known as Kanpetlet, on the slopes of Mt. Victoria.

4. Myittha Gap leads from Kalewa on the Chindwin River to Kalemyo at the foot of the hills and then to Fort White.

5. The Manipur Route leads from the Chindwin Valley to the little native state of Manipur, which occupies a plateau amongst the hills and is in communication by means of a cart road with Dimapur in Assam.

6. Tuza Gap is in the extreme north, and by it the Patkai Hills can be crossed with comparative ease.

Where these routes leave the flat land and begin to climb into the hills there are villages, which may be called frontier villages between the central basin and the hills. There is almost a continuous line of such villages along the foothills wherever the valley of a stream affords a fairly easy route. To these villages the hillsmen come down occasionally to buy extra food or a few luxuries; but the situation is singularly unhealthful, for the country is fever-ridden.

The Shan Plateau

The geographical region which has been called the Shan Plateau coincides closely in extent with the Federated Shan States and is a continuation of the Yunnan Plateau of China; and actually the Chinese do not recognize the boundary shown on British maps as

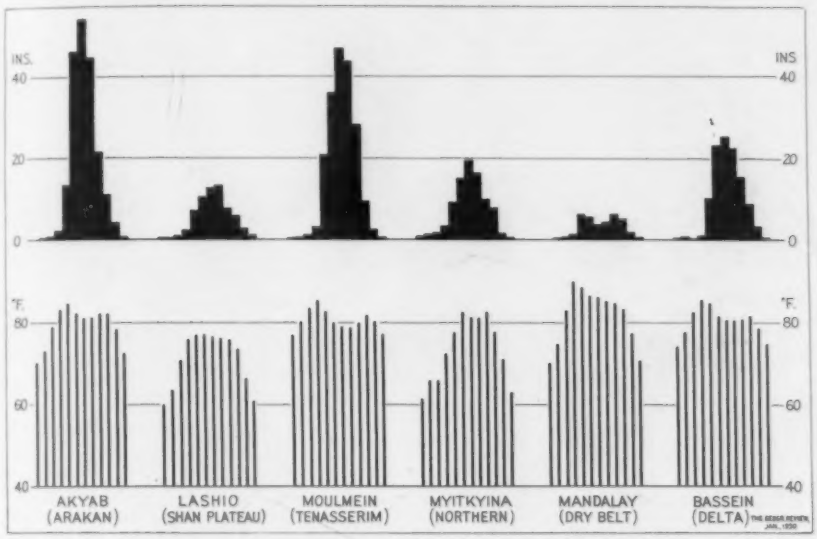

Fig. 8—Temperature and rainfall graphs for a typical station in each of the principal natural regions.

separating the Chinese Shan States from the Burmese Shan States. To the southeast the plateau merges into northern Siam, the word Siam being really the same as the word Shan. The Burmese portion of the plateau is generally between 3000 and 4000 feet high, terminated abruptly on the west where an almost continuous scarp edge, about 3000 feet in height, overlooks the Sittang and Irrawaddy valleys. The plateau is divided into western and eastern portions by the deep narrow trench occupied by the Salween River. Like most of the rivers of the region the Salween is an obstacle to communication because it interrupts the rolling surface of the plateau, although there are considerable stretches of it which are navigable.

The Shan Plateau is clothed with evergreen forests interrupted over wide areas by rolling grassland and here and there by tracts of pine forest. The whole area is an interesting example of a natural region. It was so cut off from the Irrawaddy Valley and Burma that until recently the familiar bullock cart of the lowlands was unknown there. The plateau is sparsely inhabited by hill tribes, of which the Shans are the chief but which include also Kachins, Palaungs, and Was. Special interest attaches to the last named, which are commonly divided into "tame" Was and "wild" Was. The wild Was living to

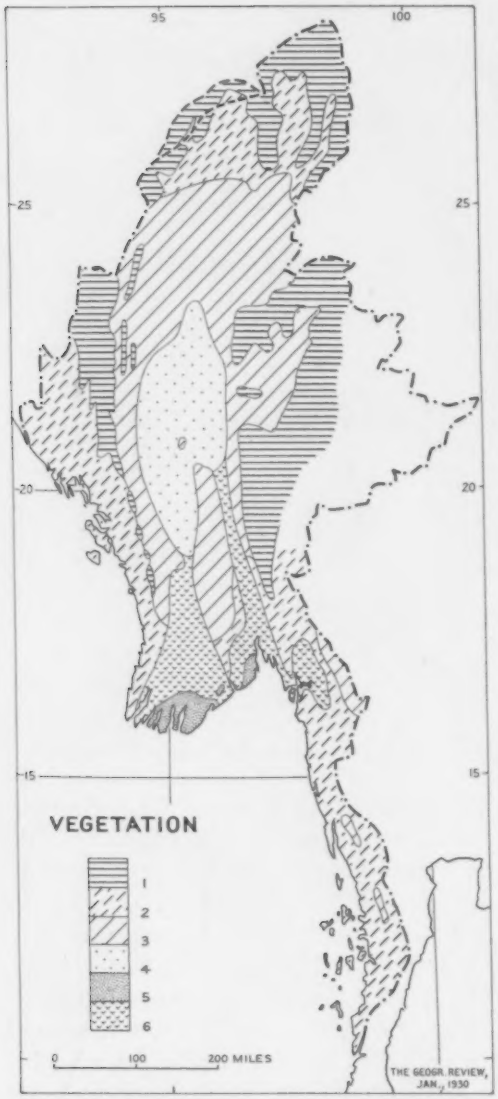

FIG. 9—Vegetation of Burma. Numbers have reference: 1, mountain vegetation; 2, evergreen tropical forests; 3, monsoon forests; 4, vegetation of the dry belt; 5, swamp forests; 6, cultivated. Based on the map accompanying the author's paper "Notes on the Vegetation of Burma," *Geogr. Journ.*, Vol. 64, 1924, pp. 231–237.

the east of the Salween still indulge on the quiet in the time-honored practice of head-hunting, and their territory has been placed out of bounds to Europeans.

There are immense tracts of rolling country suitable for crops. Rice is grown together with potatoes, vegetables of all sorts, fruits (oranges, pineapples, strawberries, etc.), and in some places wheat. Elevation tempers the climate; the rainfall throughout may be described as moderate and possibly averages about 60 inches; and it should be possible to grow large quantities of the chief crops of temperate lands. The more hilly parts of the plateau are of less importance, although in some areas the forests are of value.

Special interest attaches to the mineral resources of the Shan Plateau, of which the rocks range in age from pre-Cambrian to Jurassic. Silver has been worked in various areas by the Chinese, and it was the extensive dumps of partly smelted ore that led to the discovery of the chief silver-lead mine, the Bawdwin mine, worked by the Burma Corporation Limited. An experience never likely to be forgotten is that of suddenly coming upon the great center of activity around Namtu, where the smelting works are situated in the midst of country densely wooded, almost uninhabited, and more than 500 miles from Rangoon. In the north of the area, where a

large tract of pre-Cambrian crystalline rocks occurs, the village of Mogok lies at a height of 6000 feet in the center of a broad basin amongst the hills and for many years was the scene of the famous ruby mining of Burma. After many vicissitudes the European Burma Ruby Mines Limited finally ceased operations in 1926, though rubies and other precious stones are still obtained by native workers. Rubies occur near the junction of crystalline limestone and tongues of gneiss which are believed to be intrusive. The better stones are usually those washed out in the natural course of denudation, but others are also obtained from the solid rock *in situ*.

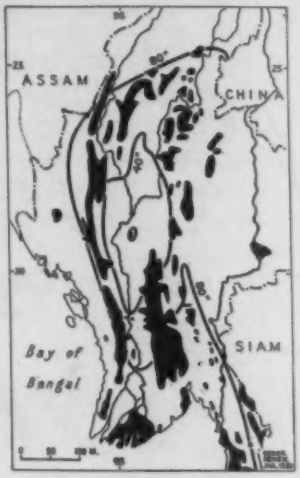

FIG. 10—The reserved forests of Burma (generalized) showing their occurrence between the 40- and 80-inch isohyets, the main exceptions being the Delta Swamp Forests and the evergreen forests of Tenasserim and the southern end of the Pegu Yoma.

Along the eastern margin certain of the districts of British Burma include fragments of the Shan Plateau, and here also certain of the larger valleys formed by rivers draining into the Irrawaddy and Sittang afford the principal means of approach from Burma proper to the Shan States. In the extreme north the Taiping Valley gives access to the Chinese province of Yunnan and is an important trade route. The town of Bhamo is situated where the Taiping joins the Irrawaddy. Farther south is the Shweli Valley, where the market town of the Chinese frontier is Namkham; still more important is the Myitnge (pronounced Mingay) Valley, which joins the Irrawaddy near Mandalay.

The principal railway into the Shan States is that from Mandalay via the hill station of Maymyo to the village of Lashio, and this railway uses the Myitnge Valley to some small extent; but the valley in many parts is too gorge-like to be a well marked line of communication. It was intended to continue this railway across the Salween at Kunlon Ferry into China, but the difficulty of crossing the Salween Valley has prevented the plan being carried out. A short private branch line runs to Namtu and the Bawdwin mines. On the Myitnge itself an important market town is Hsenwi. Farther south there is another railway into the Shan States, which leaves the main Rangoon-Mandalay line at Thazi and winds up amongst the hills to the health resort of Kalaw and on to Heho. From Heho there is a good road to Taunggyi, the headquarters of the Government of the Shan States and the center of communications. The principal villages in the Shan States are those which form capitals of states.

Southwards the Shan Plateau passes into the deeply dissected

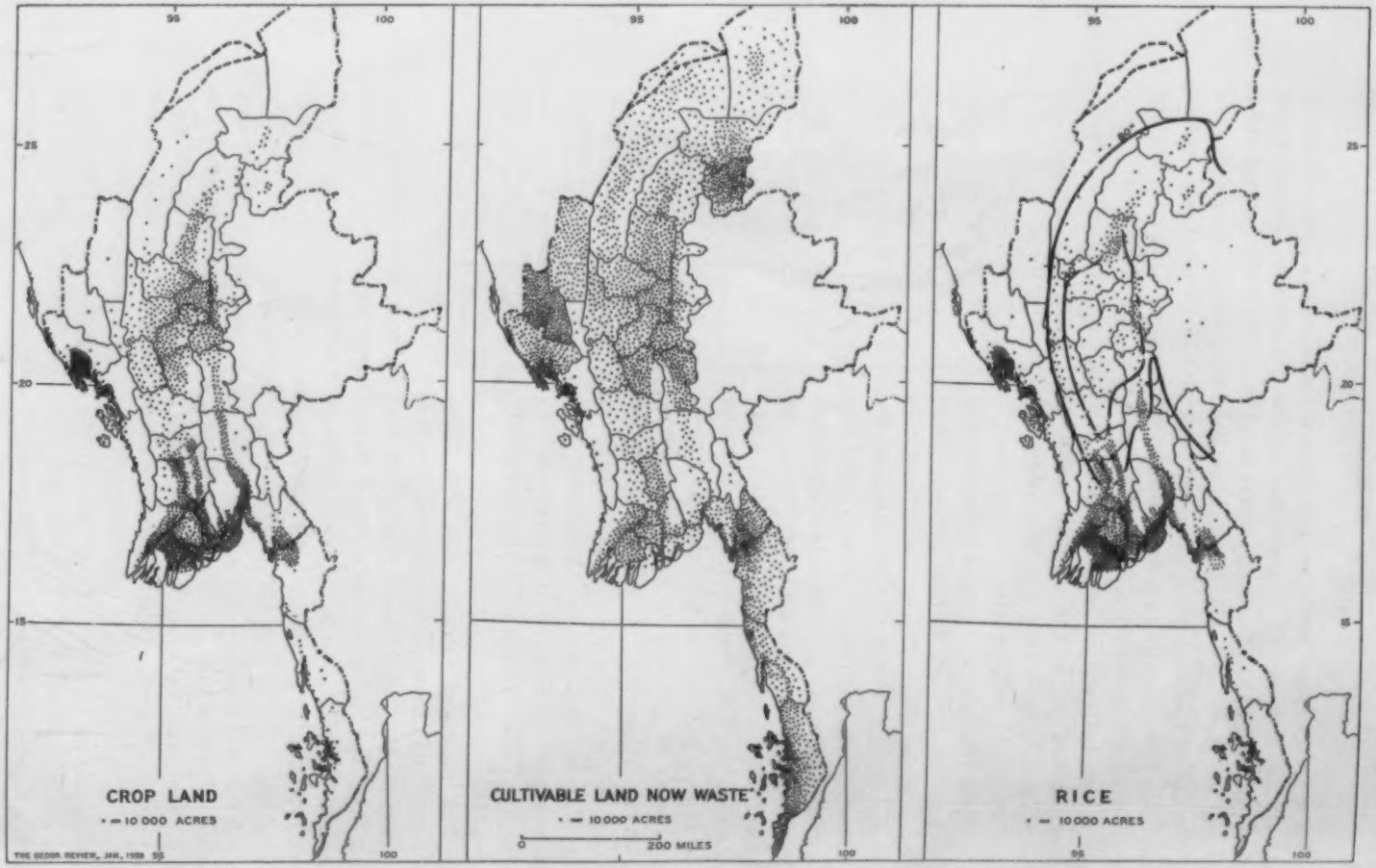

FIG. 11 FIG. 12 FIG. 13

FIGS. 11, 12, and 13—The distribution of cultivated land, cultivable land now waste, and rice in Burma. Each dot represents 10,000 acres (average of the *five years* 1922–1923 to 1926–1927). Spacing of the dots based on the writer's personal knowledge of Burma. *No details are available for the Shan States and Karenni. The heavy* lines of Figure 13 are the 60-inch and 40-inch isohyets.

country of Karenni, inhabited almost entirely by Karens and drained by the Salween and its tributaries. This area is reached from the port of Moulmein.

Tenasserim

The natural region of Tenasserim corresponds almost exactly with the division of the same name and lies between the crest of the Tenasserim Yoma, which in most places forms the frontier with Siam, on the east and the Gulf of Martaban on the west. Structurally the area consists for the most part of a complex of sedimentary rocks, especially hardened shales and slates, which has been penetrated by large granitic masses. These granitic masses are much elongated in a north-and-south direction and give rise to long ridges separated by valleys which represent the outcrops of the softer sedimentary rocks.

In the north-and-south alignment of the physical features the region resembles Arakan, but geologically the two areas are entirely distinct. Like Arakan, the coast is varied in character but is fringed with innumerable islands. Where the islands are formed of granite masses they are rugged, lofty, and covered with evergreen forests of equatorial type; where the islands consist of sedimentary rocks they have often been worn down almost to sea level and are clothed with extensive mangrove swamps. As in Arakan, settlement is mainly restricted to suitable areas of flat land; and by far the most important tract of cultivated land is the alluvial plain lying in the immediate hinterland of Moulmein—a tract given over almost entirely to rice cultivation. In this northern area vertical-sided limestone hills form a characteristic feature of the topography. Associated with the margins of the granite masses are the well known tin and tungsten deposits of Lower Burma, the occurrence of the tin being similar to that of the region farther south in Malaya.

Climatically the region has a heavy rainfall (Thaton, 218 inches; Amherst, 189; Tavoy, 215; Mergui, 163): it differs from Arakan in that the dry season is much shorter. It is largely for this reason that the climate of Tenasserim has proved suitable for rubber planting. Plantations now cover large areas near Tavoy and Mergui. As in Arakan, fishing is important; but the pearling grounds of the Mergui Archipelago are less important than formerly. Many of the smaller islands of the archipelago are inhabited by very primitive peoples, often called the sea gypsies. It is difficult to imagine a more beautiful part of the world than the Mergui Archipelago. Sheltered from severe storms by an outer fringe of islands, one may cruise for days in the shallow waters; and there is an unending variety in the scene as one rounds successive headlands, stopping occasionally at some little fishing village that consists of bamboo huts built out over the water and backed by the vivid green of the dense forest.

FIG. 11

FIGS. 11, 12, and 13.—The distribution of cultivated land, cultivable land now waste, and rice in Burma. Each dot represents 10,000 acres (average of the five years 1922–1923 to 1926–1927). Spacing of the dots based on the writer's personal knowledge of Burma. No details are available for the Shan States and Karenni. The heavy lines of figure 11 are the outlines used on the maps of figures 12 and 13

The most important town in the region is Moulmein, near the mouth of the Salween. Sheltered from the sea by Bilugyun Island, it is a port for the rice lands of the northern part of Tenasserim, as well as for the teak from the forests of the Siamese frontier. Since the connection of the town of Martaban on the opposite bank of the Salween by railway with Rangoon, Moulmein has tended to become less important. There is now a railway running southwards from Moulmein to Ye, which will eventually be carried on to Tavoy. The position of Mergui with relation to a fairly easy pass across the mountains into Siam is interesting because a railway is to be constructed along this route, and it seems that Mergui is destined to become an important port of Siam.

Quite apart from the large area of Tenasserim not available for cultivation, being occupied by forests, mountains, etc., there is a huge area of waste but cultivable land which awaits development. The excessive rainfall, which often washes the planted seeds out of the ground and may wash away the soil entirely, is the chief drawback.

The Northern Hills Region

The northern part of the great central basin on the whole slopes southwards from the mountain rim and is drained by the Chindwin on the west and the upper course of the Irrawaddy on the east. The Irrawaddy is formed by the junction of two streams, the Mali-Kha and the Nmai-Kha, both of which rise within Burma itself. The hilly and mountainous northern parts of this region are inhabited by hill tribes. The country between the Chindwin and the Irrawaddy is the great Kachin area, whilst the upper part of the Chindwin Valley, usually called the Hukawng Valley, is inhabited by Shans. Some of the wilder parts are still "unadministered," that is they do not come under the direct administration of the Government of Burma. One of these unadministered areas is the famous triangle between the Mali-Kha and the Nmai-Kha rivers, where strenuous efforts have been made in the last five years to abolish slavery. The fertile valleys of the Chindwin, the Mu, and the Irrawaddy in the south of the region are inhabited mainly by Burmans. The Burma Railway's most northern station is Myitkyina; but some idea of the size of the country may be gained by saying that Myitkyina is still 290 miles by mule track from Putao, the northernmost administrative center. The famous jade of Burma, most of which finds its way to China, comes from the hills north of Mogaung; amber is obtained from the Hukawng Valley; and there is a small oil field in the Chindwin Valley at Indaw.

The mountains of the north are clothed with dense forest, consisting largely of rhododendron in the higher parts but of pines in some areas. In the wettest regions of the lower country are dense evergreen forests

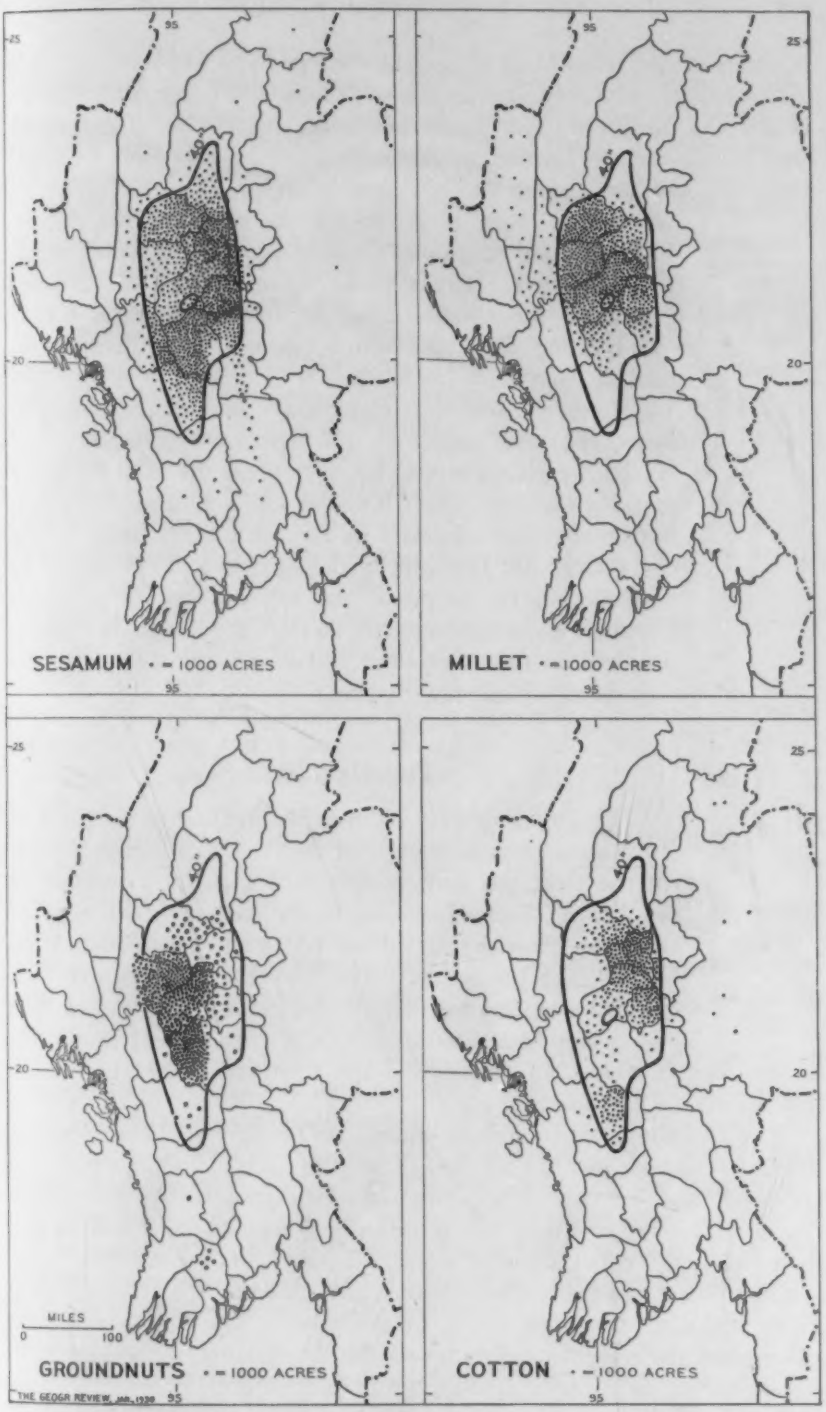

FIG. 14—The distribution of sesamum, millet, groundnuts, and cotton in Burma. Each dot represents 1000 acres (average of the five years 1922–1923 to 1926–1927). The heavy line is the 40-inch isohyet.

of dipterocarps, resembling in general the forests of Tenasserim. Farther south are rich monsoon forests with teak and other timber trees. Where the forests are reasonably accessible the timber is extracted. Southwards this region merges gradually into the Dry Belt. Except along the southern fringe the hill area is undeveloped and sparsely inhabited. Rice is grown for the needs of the people, but there are enormous areas of waste land which might be cultivated. The Chinese have penetrated to some extent in the neighborhood of Bhamo, but the Indian immigration from the south has scarcely affected this part of Burma.

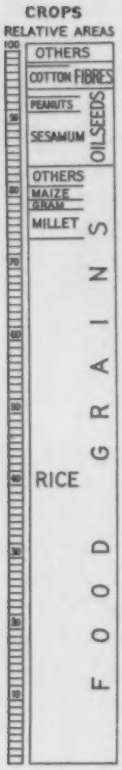

FIG. 15

There are few important towns or villages, the chief being the river ports on the Irrawaddy, Bhamo, and Katha, which are served by river steamers from Rangoon and Mandalay. The Chindwin also is navigable by flat-bottomed river steamers as far north as Pantha in the dry season and Homalin in the wet season. It should be noticed that the slope of the hill country in northern Burma is towards the south, so that the "outlook" of the people is in that direction; and it is from central Burma that development must come.

THE DRY BELT

The Dry Belt may be roughly defined as the part of Burma that has a rainfall of less than 40 inches a year. To the west the limit corresponds with the boundary of the Arakan Yoma foothills, to the east with the edge of the Shan Plateau, but to the north and south there is no well defined boundary. The Dry Belt as a whole is a lowland area, interrupted at intervals by low lines of hills and centering around the conspicuous central mountain known as Mt. Popa, an extinct volcano towering more than 4000 feet above the surrounding plain.

The Dry Belt consists almost entirely of Tertiary sediments, whose character determines the character of the soils. Large areas are occupied by the coarse Irrawaddian sands, giving rise to very light sandy soils. Other areas are occupied by mixed clays and sandy shales of the Peguan, giving slightly heavier and sometimes very fertile soils but in other cases soils that are ruined by a high alkalinity. There are also extensive tracts of alluvium. These differences in soil explain the irregular character of the distribution of the Dry Belt crops—millet, sesamum, cotton, groundnuts, etc. Certain areas of the Dry Belt have been irrigated, especially round Yamethin and Kyaukse, by streams from the Shan Plateau; in the Shwebo district

by streams from the northern hills; and in the Minbu district by streams from the Arakan Yoma. But no use whatever has yet been made of the huge supplies of water in the Chindwin and Irrawaddy. Burma is still in the stage of development when the principal use of rivers is for navigation.

The Dry Belt is, however, the natural heart of Burma; and, so long as Burma remained an independent kingdom or a land empire, it was natural that the capital of the country should be here. No less than seven former Burmese capitals lie in the heart of the Dry Belt: Mandalay, Amarapura, Ava, Sagaing, Pagan, Shwebo, and Tagaung. All parts of the country are comparatively easily accessible from this central region. For example, the natural roads from Mandalay include that via the Upper Irrawaddy to Bhamo and China, that via the Chindwin to Manipur, that via the Lower Irrawaddy to Prome and Rangoon, that via the Sittang to Pegu and Tenasserim, and finally that via the Myitnge to China.

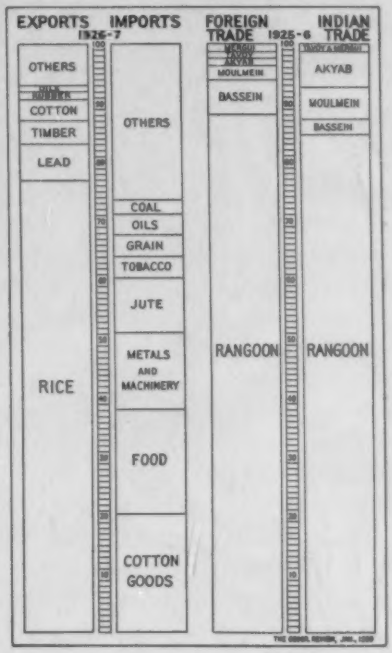

FIG. 16—Diagrams showing the composition of Burmese exports and imports and the relative importance of Burmese ports in foreign and Indian trade.

The Dry Belt of Burma is essentially an agricultural region; the principal towns are those river ports which act as collecting stations for agricultural products. A long line of them is strung out on the river—Monywa, Mandalay, Pakokku, Myingyan, Minbu, Magwe, Allanmyo, and Thayetmyo being good examples. The other chief towns are those on the railway from Mandalay to Rangoon.[3]

In the heart of the Dry Belt are the great oil fields,[4] the two chief being the famous little field of Yenangyaung and the increasingly important field of Singu; but again the backwardness of Burma is emphasized when one finds there is no railway nor motor road to either Yenangyaung or Singu, and the minimum time occupied by the journey to these towns from Rangoon is two days.

[3] Burma is essentially rural; there are only eleven towns with more than 10,000 people (1921), including two with more than 100,000—Rangoon 317,687; Mandalay 142,642.

[4] See the author's papers: The Geology of the Oilfields of Burma, *Journ. Amer. Assn. Petroleum Geologists*, Vol. 11, 1927, pp. 553–579; Oilfields of Burma, *Journ. Instn. Petroleum Technologists*, Vol. 15, 1929, pp. 300–345.

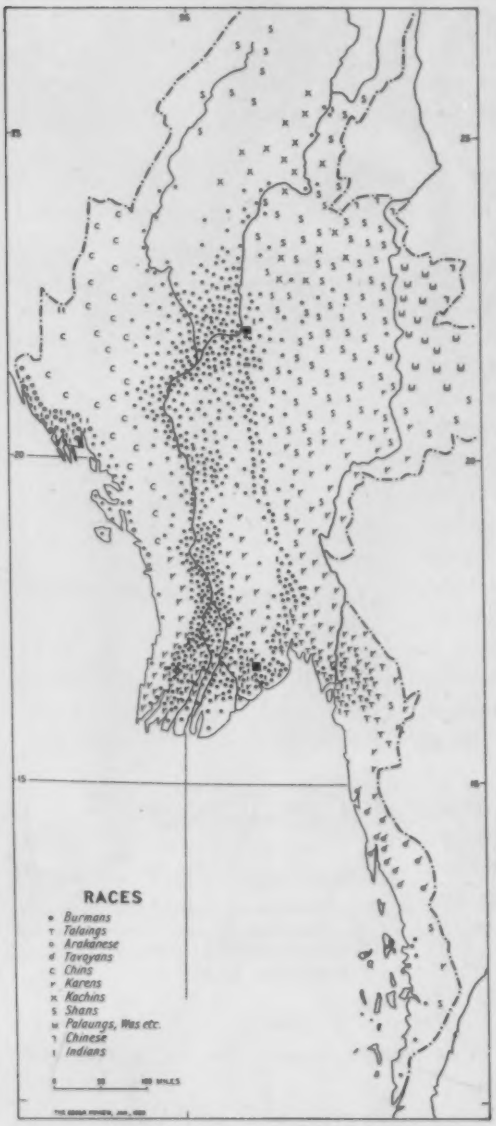

FIG. 17—Map showing the distribution of races in Burma. Each symbol represents 10,000 people.

THE LOWER IRRAWADDY VALLEY AND DELTA

The great delta of the Irrawaddy forms a triangle with its apex roughly at the town of Henzada. Northwards from Henzada as far as Prome there is a stretch of alluvial agricultural land which, for purposes of description, may be linked with the delta. The whole region is of course a lowland, with low sandy ridges appearing especially in the north. Henzada has a rainfall of 84 inches a year, and the whole of the delta proper has a rainfall of over 80 inches—usually between 80 and 120. Northwards from Henzada the rainfall decreases as one approaches the Dry Belt, and Prome has 47 inches. This region is the most thickly populated part of Burma; the inhabitants are still mostly Burmans, but scattered amongst the Burmese villages are villages inhabited entirely by Karens. Many Indians are employed as coolies, and this region is feeling the pressure of Indian immigration. A far larger proportion of the land is cultivated here than in any other part of Burma though even here a considerable proportion can still be classed as waste. Along the seaward fringe of the delta are large areas of tidal forest. The principal tree is the *kanazo*, which furnishes important supplies of timber and of fuel for the delta towns. Elsewhere rice cultivation is overwhelmingly the most important occupation. Other crops include beans, tobacco, fruits, vegetables, maize, and betel nuts.

Communications throughout the delta proper are almost entirely by water; the principal towns are rice-collecting centers, such as Bassein, which serves the western part of the region, Pyapon, Myaungmya, Dedaye, Wakema, Moulmeingyun, and Ma-ubin. Rice for export or milling is sent by paddy boat either to Rangoon or to Bassein. A railway from Rangoon skirts the two northern sides of the deltaic triangle, crossing the Irrawaddy by a ferry at Henzada and terminating at Bassein. The principal danger in the delta is flood, against which large areas are protected by bunds. The rainfall is always sufficient for rice cultivation.

The Pegu Yoma

The Pegu Yoma is a low range of forested hills lying between the Irrawaddy and the Sittang valleys. On either side the junction is clearly defined, and the forests are particularly important because of their accessibility and their nearness to Rangoon. The northern end of the range merges into the Dry Belt; the southern end has a rainfall of over 80 inches and so is clothed with evergreen forest. The central portion has the important teak forests. These forests would have been worked out long ago had it not been for the careful policy of the Government. The timber extracted is floated downstream in the rainy season, either by the Hlaing River to Rangoon on the west, or on the east by the Sittang River and thence by canal to Pegu and Rangoon.

The Pegu Yoma forms a very sparsely populated tract, the only inhabitants being a few Karens. Despite the fact that the hills rarely reach an elevation of over 2000 feet the presence of steep scarp slopes renders crossing difficult. Only recently has a railway been taken across the hills towards the northern end from Pyinmana to Taungdwingyi.

The Sittang Valley

The valley and delta of the Sittang form a much smaller area than those of the Irrawaddy, but they have the same rich alluvial soil; and this much smaller area provides no less than one-fifth of all the rice grown in Burma. The Sittang is used for floating timber but is not navigable except by small boats, and so the railway forms the principal line of communication through the region, the railway towns flourishing while the river towns, such as Shwegyun, have declined in importance.

Conclusion

A geographical study of Burma is thus a study of a country of immense possibilities and one in which extensive development may be expected in the near future. From what has been said it is obvious

that there is still a very large proportion of waste land. Actually only 11 per cent of the total area is under crops while 38 per cent now waste is cultivable. Forests cover over 12 per cent, fallow occupies between two and three per cent (average for 1923–1927). Little expan-

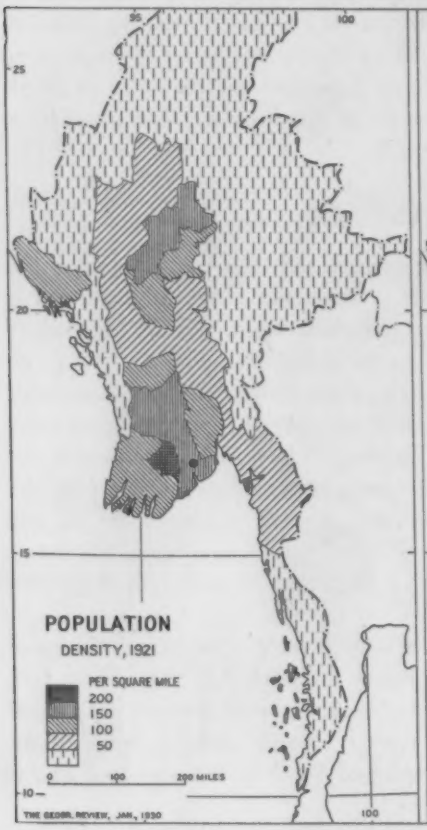

FIG. 18

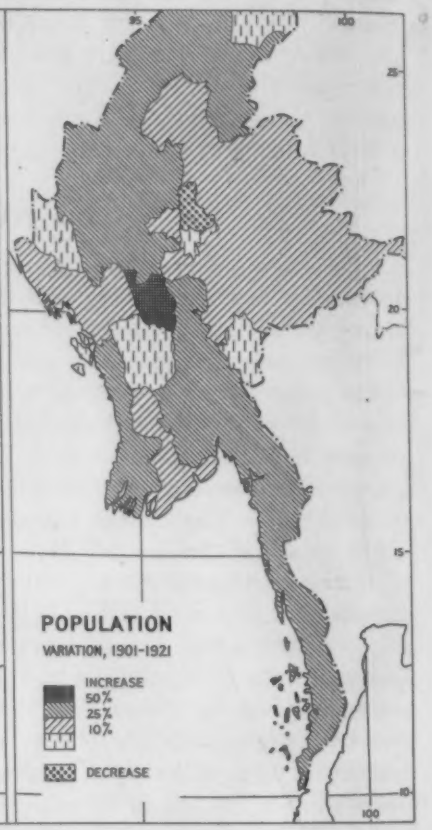

FIG. 19

FIG. 18—Density of population in Burma by districts, census of 1921. The average density for the whole of India is 177.

FIG. 19—Variation in population in Burma 1901–1921. The period 1911–1921 does not give a reliable index of natural increase because of the influenza epidemic of 1918.

sion is possible in areas already reached by railway or well marked lines of water communication, and further development of communications will necessarily play a large part in the development of waste land. There is every reason to believe that wheat and barley could be successfully grown on the Shan Plateau or in the Dry Belt, but Burma does not receive the slight showers of winter rain that are so valuable in the Punjab and has not yet the irrigation facilities to supply that moisture when it is needed. Obviously these are crops which would call for attention when Burma is more developed than it is now.

Forests of valuable timber cover at least 130,000 square miles—over half the total area of country. The Government Forest Reserves cover only about 30,000 square miles of this total. Teak, and to a much less extent pyengadu, are the only timbers which have been

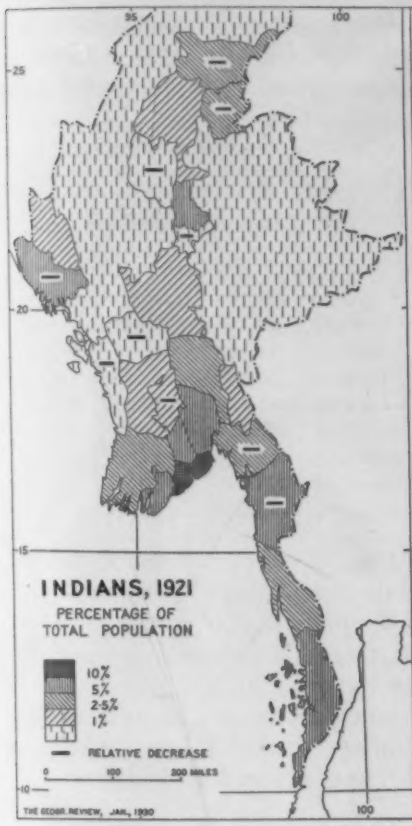

FIG. 20

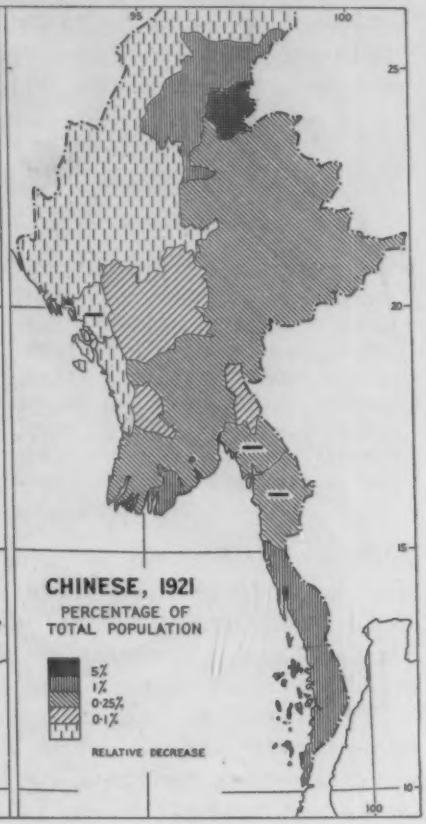

FIG. 21

FIG. 20—The Indians in Burma. The figures show the percentage in each district according to the Census of 1921. The Indians increased relatively to the total population in the period 1901–1921 except in those districts marked with a minus sign.

FIG. 21—The Chinese in Burma. In the period 1901–1921 the Chinese increased relatively to the total population in every district except those three marked with a minus sign.

seriously exploited, and teak is the only one known outside India. It would be hard to find another part of the British Empire where the timber resources are so extensive, so varied, so accessible, and yet so little appreciated. Yet once the many other valuable timbers of Burma become known, there can be no doubt that they will be in great demand in European markets.

Burma offers a very important field of immigration for Indians as well as for the other races of the East. There are now over a million

Indians in Burma, drawn mainly from Madras, Bihar and Orissa, and Bengal, and their number is rapidly increasing. Many of them come annually to work as coolies in the docks of Rangoon or on the railways and in all the larger towns and villages, others as traders. In many cases the immigrants leave their womenfolk behind, and their wages are sent out of the country to their families in India. Apart from this temporary immigration, large numbers of Indians arrive and settle permanently; or, more correctly, the immigrant coolie finds conditions

IMMIGRATION INTO BURMA BY SEA (MAINLY THROUGH RANGOON)

YEAR	ARRIVALS	DEPARTURES	NET INCREASE	YEAR	ARRIVALS	DEPARTURES	NET INCREASE
1911–12	368,383	311,574	56,809	1919–20	284,779	219,087	65,692
1912–13	327,582	331,520	−3,938	1920–21	341,180	316,837	24,343
1913–14	380,216	355,397	24,819	1921–22	331,992	303,806	28,186
1914–15	268,416	146,285	122,131	1922–23	360,038	310,331	49,707
1915–16	338,890	249,076	89,814	1923–24	382,724	295,320	87,404
1916–17	258,841	252,348	6,493	1924–25	388,205	315,833	72,372
1917–18	223,133	237,184	−14,051	1925–26	372,733	350,974	21,759
1918–19	259,922	234,237	25,685	1926–27	408,464	342,597	65,867

in Burma so much more favorable than in his own country that he sends home enough money for his wife and family to join him. The Indian settlers do not stray far from the main lines of communication. They are found in numbers wherever there is a railway but especially in the delta regions in the vicinity of Rangoon.

The Chinese also form an important community. Except on the frontier in the northeast, where Yunnanese and Chinese coolies are found as well as merchants, the Chinese belong essentially to the artisan and merchant classes. No one who has traveled in Indo-China or the East Indies can fail to have been struck by the large Chinese immigration. Nowhere is this more marked than in Malaya, but the state of affairs in Burma is peculiar to that country. In Rangoon the Chinese Chamber of Commerce has been sufficiently powerful absolutely to prevent the immigration of Chinese coolies or laborers, so that one never finds in Rangoon a Chinese in competition with an Indian coolie. Instead, they form a distinctly higher substratum of society quite definitely marked. The Chinese gradually penetrate upcountry, and it is usually a sign that a Burmese village is becoming large enough to be called a town when a Chinese family arrives and opens a pawnshop.

Indians and Burmans are racially distinct, and intermarriage is regarded unfavorably, especially by the Burmans, who consider themselves decidedly superior. On the other hand Chinese-Burmese

marriages are acceptable to both races, and the children tend to be absorbed into the Burmese community.

Enough has been said in this paper to illustrate the great difference between Burma and India proper and to supply a background for the political and economic developments likely in the near future. Burma desires separation from India, for at present Burma pays more to India than she receives in return; and this Cinderella province has but a small voice in the Indian legislature. India establishes a protective duty on imported iron and steel to encourage her nascent industry; Burma also pays the duty but has no industry to protect. Burma, a happy land of happy people, desires to be freed from the troubled politics of India and to develop along her own lines.

THE HISTORY OF POPULATION AND SETTLEMENT IN EURASIA

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THE study of economic geography, which has made such rapid advances in recent years, presents many questions closely related to the history of population and settlement. Vidal de la Blache was keenly aware of these contacts with history, and his last work, "Principles of Human Geography," contained much historical material. The full appreciation of certain problems of economic geography requires, however, a systematic study of the process of settlement, because the nature of social adaptations to resources must ultimately be treated as a concrete problem in the history of settlement. Many writers have believed that there were no data sufficiently trustworthy to admit of even the most general sketch of the history of settlement in Eurasia, but important work has been brought out latterly, and the larger aspects of the process of settlement can now be established. Many details are wanting; the conclusions must be interpreted with care; but suggestive and important results are now attainable.

Of the categories that may be applied to the process of settlement only one is a common use, "frontier," a well known term though of ill defined content. We commonly associate the term with low densities of population, irrespective of the relation of the condition of the region to a process of settlement. Semiarid steppe is incapable of supporting more than a thin nomadic or seminomadic population. Such regions are "fully" settled even when the absolute density is low. Should the term "frontier" refer to absolutely low densities or should it apply exclusively to early stages in the process of settlement? The latter use of the term seems likely to be the more significant. The other aspect of the problem is adequately met by setting up a separate classification—maturely settled regions with low densities.

In a region in process of settlement, there is a stage intermediate between anything that can be legitimately termed "frontier" settlement and the complete occupation of the country that we may describe as mature settlement. Many of the economic problems of the intermediate stage of settlement are dominated by the presence of "free," or unoccupied, land; but it would seem desirable to distinguish between frontier conditions and such intermediate problems at the stage in settlement when agriculture begins to achieve sufficient

adaptation to the character of the region to produce, in some portions of the settled area, well defined methods and types. The intermediate stage is concerned with the diffusion of these characteristic types over the whole area, just as the frontier stage is concerned with the development of the primary types of culture appropriate to the region.

These categories of settlement can scarcely be identified with specific density intervals, because the potentialities of different regions vary enormously. There are considerable differences in the north temperate countries of Europe and America, but still wider range in India and China. Obviously, the density of population under mature settlement is profoundly influenced by all the characteristics of the region. In so far as it is possible to establish regional types, density intervals can be given that are roughly significant in discriminating between mature and intermediate settlement. It is doubtful if any density figures for large regions can be of much significance in distinguishing the transition between frontier conditions and intermediate conditions of settlement.

Frontiers are of two types, border frontiers and included frontiers. The first of these types is most familiar today and by far the most explicit. In such regions there is a well defined boundary line between the occupied and unoccupied land and between the areas of tentative and incomplete occupation and the forms of settled agriculture characteristic of intermediate stages of settlement. This type has dominated the history of the newer countries of the nineteenth century in the United States, Canada, Australia, and some of the South American countries.

In the history of Eurasia since the beginning of the Christian era frontiers have never been of such a type. At the dawn of history there were inhabitants in practically the entire area, pursuing methods of agriculture that were not negligible. Population was sparse, agricultural technique rudimentary, and much of the best land uncleared or unoccupied. Settlement was localized for various reasons—political, military, and economic. The frontier character of settlement lay in the distances between the occupied localities and in the extensive type of exploitation predominant. Conditions in Gaul in Caesar's time are fairly representative of this phase, which probably is the typical form of the frontier throughout the history of Eurasia. The distinction between such a frontier and early stages of intermediate settlement is not sufficiently explicit to be defined with rigor. The distinction must needs be based upon the technique of agriculture rather than upon any map of settlement or any specific density figure, whether absolute or relative to the presumed density of population in the region when maturely settled. It would be tempting, for instance, to say that the transition from the frontier condition takes place when the density first exceeds one-fourth or one-third of the

mature density. This would be, however, a rather arbitrary solution of a problem that does not require so specific an answer.

Maturity of settlement is indicated by stabilization of population and complete occupation of the area capable of exploitation. At this point the pressure of subsistence upon population begins to manifest itself most clearly. No further growth of population is possible under the established type of culture. The attainment of this stage, however, does not preclude further growth if technical advance signally increases the resources that may effectively be exploited. Thus, the changes occurring in Europe between 1750 and 1850 opened up new potentialities in the utilization of minerals and reorganized the mechanisms of marine and land transport upon so commanding a scale that the relation of resources to economic activity was completely transformed. Before these changes the resources effectively exploited were predominantly agricultural; forests and grazing areas constituted important adjuncts, subject to somewhat similar conditions of limitation. The utilization of minerals was restricted within a narrow field. The development of massive utilization of minerals and mineral products was revolutionary in its effect. The change is of such importance historically that one must use the term "mature settlement" in somewhat different meanings before and after it.

In India and China, at the present time, considerable areas may be properly described as maturely settled, although the full development of mineral resources would probably make possible further growth of population. Consideration of these phases of mature settlement thus shows that in this instance also the attempt to identify such a stage with specific densities of population is likely to be misleading. Although mature settlement is commonly associated with stabilization, it is not a "static" condition. The history of China, too, suggests that relative stabilization may take place during some intermediate stage in settlement.

Materials for Population Study

The comprehensive enumerations of population characteristic of modern statistical procedure were systematically begun only in the middle of the eighteenth century and were not general even among the principal European countries until the early part of the nineteenth century. Some enumerations of individuals were made in some of the Italian states during the sixteenth century and perhaps elsewhere in Europe, but they were confined to the bare enumeration of the population without the details of age and marital condition that distinguish the series begun in Sweden in the middle of the eighteenth century. Experience has shown the difficulty of securing high standards of accuracy even when the purpose of the enumeration is freed

from all elements of political and economic bias, and it is thus with good reason that early materials on population have been treated with suspicion and even disdain.

All the early materials suffer from the elements of error that are most dreaded by the modern statistician: the enumerations include only a portion of the population, and thus the absolute figure can be computed only by using some more or less arbitrary coefficient; the enumeration, such as it is, suffers too from the undoubtedly serious intrusion of administrative interests and popular apprehension. Whether the records were to be used as a basis for military levy or as a basis of taxation, both the officials and the objects of their solicitude had interests in various kinds of inaccuracies and omissions. It must be admitted, therefore, that no early records relating to population can be regarded as an adequate basis for judgments of the absolute population. But it does not necessarily follow that these records are without importance. The broader problems in the history of population do not require minute accuracy in respect of the absolute population; we need some knowledge of the relative population of different areas, and we need some knowledge of the secular trend of the growth of population over long periods of time. Changes in the mass of population are relatively slow over long periods of time when conditions are stabilized, but profound changes may take place within a century or two during periods of active growth. Small fluctuations in population are thus of little significance during periods of stabilization, and the fact of growth is too conspicuous to be obscured even by rough approximations when notable growth occurs.

It is possible, too, to exercise no little control over early estimates of population. Figures for large areas not available in much detail can frequently be checked by details available for a portion of the area. It is thus possible to discover whether the more general figures are in fact based upon an actual enumeration of some kind or whether they are mere unsupported guesses by a person without comprehension of the meaning of numbers. Quintanilla's figures for Spain in the late fifteenth century can thus be excluded from serious consideration.[1] Many statements about population in antiquity can similarly be shown to have no serious statistical value. More important, however, are the presumptions that can be formed about densities of population upon the area in question through knowledge of well ascertained densities in areas of similar economic condition. The characteristics of irrigated regions are quite specific, and no less so the features of settlement in Mediterranean countries and in northwestern Europe. There are certain norms of expectation which constitute a rough basis for the control and interpretation of results.

[1] Konrad Häbler: Die wirtschaftliche Blüte Spaniens im 16. Jahrhundert und ihr Verfall, Berlin, 1888.

The elements of error in early data lead towards an estimate that is unduly low rather than towards an excessively high figure. We have, thus, partial enumerations of several classes: "families," in the sense of the members of a household; the male population of military age; the entire "adult" population; lastly, various kinds of enumerations of taxable persons. The computation of the total population from any of these partial enumerations involves evident uncertainties. The coefficients used, if chosen conservatively, will probably be too small, especially if we attempt to use the proportions of the age groups derived from modern figures. Heavy mortality in the lower age groups more than offsets the lower expectations of life among the adults. The magnitude of probable error from these sources would scarcely exceed ten per cent. The computation from the number of "families" is most uncertain, but the absolute population would scarcely be less than four nor more than five times the number of families: the use of the mean coefficient 4.5 thus leaves a possible error of ten per cent.

The probable error from omissions of persons presumed to be enumerated is of course utterly incalculable. Careful study of the full detail of the series of figures commonly throws some light on the question. Comparison of enumerations with each other is even more illuminating. When details are available it is usually possible to detect serious omissions and thus to select from the mass of material the portion which is most trustworthy. Even the best figures will inevitably contain some omissions, so that, for purpose of modern comparisons, as much as twenty per cent is frequently added to the results of direct computation from the contemporary records. Over fairly large areas the estimates from carefully selected materials will probably be, at best, within ten per cent of the absolute population.

The merits of such partial enumerations are shown best perhaps by the computations of the population of England since the Elizabethan period by John Rickman.[2] Reports of total births, deaths, and marriages were secured from the parish registers, so that the enumeration was modern though the original records were contemporary. Estimates were made upon each basis, and an average was taken of the results. The final figures constitute a series that connects with the actual census returns in 1801, with an error of about three per cent. Unless one assumes an extraordinary degree of chance in the distribution of probable errors, this series for England from 1570 to 1800 must exhibit the primary features of the trend of population in England and Wales both for the area as a whole and for the counties. For

[2] Census of Population: Great Britain, 1841. Introduction. Estimated Population of England and Wales, 1570–1750. Commons Papers, Session of 1843, Vol. 22.

There are earlier studies for the eighteenth century available in the census reports for 1811 and 1831.

relatively long periods of time such a series is of genuine value, but figures obtained by such methods would obviously be of little value for any study of the changes of population from year to year.

One of the serious hazards in the study of early materials on population is the question of the extent of the area enumerated. Whether the computation is made for some modern political area or for the contemporary area, some bridge must be found between modern surveys and the contemporary political divisions. In England and in China the older administrative divisions have survived without significant change. In France the areas of the administrative divisions of the old régime were computed when the modern statistical surveys were made in the nineteenth century under the supervision of Moreau de Jonnes. Careful study of the sixteenth century enumerations in Spain shows that the modern provinces correspond to the older administrative divisions except in old and new Castile, so that modern figures for areas can be used for a large portion of the country. The areas capable of settlement in Egypt and Mesopotamia have been computed by modern engineers. The areas of the older political divisions in other regions can be computed only by some one of the various planimetric methods. With large maps and substantial care in the demarcation of the areas to be measured, the errors would not be serious, though the figures obtained would be approximations only.

Study of population has much to gain from direct reduction of all estimates to density figures in terms of the contemporary political divisions. If the known results are then marked on the map, as much has been done as is wise. If the returns do not cover the entire area it is safer to leave blank spaces on the map or in the table than to attempt to estimate the population of the unrecorded areas by pure inference. The dangers of the latter course are illustrated in the data at hand for Italy and Spain, which disclose important displacements of population within the larger regions even when there are no significant changes in the total population. Beloch took an important step forward in recognizing the necessity of careful computation of areas, but in his work on the Middle Ages and early modern period he still remained under the influence of the older notion that a statement for the modern political divisions must be the ultimate end of such statistical studies.

Europe and the Near East at the Time of Augustus

Although some data are available for Greece and parts of Italy before the establishment of the Roman Empire it is scarcely necessary to review those materials in the present essay. The figures disclose rather notably the facts that are clearly implicit in the general history

of the period. There was a steady drift of population westward, culminating in the migrations from peninsular Greece after the age of Pericles. Apart from the trading colonies in Egypt and the Levant, these migrations were the outcome of the opportunities for frontier colonization in Italy and the western Mediterranean. The settlement

TABLE I—POPULATION OF THE ROMAN EMPIRE AT DEATH OF AUGUSTUS, 14 A. D.

COUNTRY	POPULATION (*In millions*)	AREA (*In thousands of square kilometers*)	DENSITY	
			Per sq. km.	*Per sq. m.*
EUROPE	23	2,231	10	26
Italy	6	250	24	62.2
Sicily	0.6	26	23	59.5
Sardinia and Corsica	0.5	33	15	39
Narbonensis	1.5	100	15	39
Three Gauls	3.4	535	6.3	16.3
Danube	2.0	430	4.7	12.2
Greece	3.0	267	11	28.6
Spain	6.	590	10	26
ASIA	19.5	665.5	30	77.5
Province of Asia	6	135	44	114
Rest of Asia Minor	7	412	17	44
Syria	6	109	55	143
Cyprus	.5	9.5	52	135
CONTINENTAL AFRICA	11.5	443	26	67.5
Egypt	5.0	28	179	465.0
Cyrenaica	.5	15	33	85.5
Africa (Province)	6.0	400	15	39.0
TOTAL ROMAN EMPIRE	54.0	3,339.5	16	41.5

of the Mediterranean littoral was not completed much before the establishment of the Roman Empire.[3] Caesar's expeditions into Gaul constitute the natural line of demarcation between the completion of an important stage in the history of the settlement of the west and the opening of a new frontier whose mature settlement was destined to occupy the next 1500 years. The computations of the population of the Empire at the death of Augustus thus afford a rough index of conditions at one of the most important periods in the history of the settlement of the western world.

The earlier estimates of Beloch are given in Table I.[4] The estimate

[3] Julius Beloch: Die Bevölkerung der griechisch-römischen Welt, Leipzig, 1886, pp. 161–222, 506.

[4] Beloch, *op.cit.*, p. 507. See also his articles: Die Bevölkerung im Altertum, *Zeitschr. für Socialwiss.*, Vol. 2, 1899, pp. 505–514; Die Bevölkerung Italiens im Altertum, *Klio*, Vol. 3, 1903, pp. 471–490. Seeck's criticisms and Beloch's replies appear in *Jahrbücher für Nationalökonomie und Statistik*, Vol. 68, 1897, pp. 161–176 and 321–343.

for Italy has been somewhat increased in a later discussion of the problem by Beloch, and some new data have become available for small areas in the Near East. In general, however, the table stands as the best estimate now possible to make. The materials used in the preparation of the table are far from being homogeneous, so that full critical discussion runs to great length. The importance of the problem would warrant a comprehensive revision of the entire table, but until that large task is completed the work of Beloch is our safest guide. The figures are doubtless the lowest that could be justified from the sources; nearly all of them could be increased without reaching results that would be at all improbable.

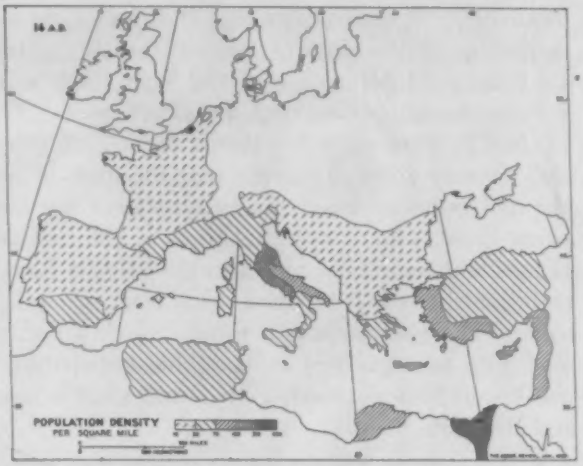


FIG. 1—Population density in the Roman Empire at the beginning of the Christian era (death of Augustus, 14 A. D.).

The geographical aspects of the materials will be most readily perceived in Figure 1, which, except for Italy and Greece, is based directly upon the data presented in the table. Upon the basis of the enumeration of towns and villages for the twelve regions of Italy, an attempt has been made to distinguish between the gradations of density in the peninsula. The results are sufficiently consistent with earlier returns to be highly probable, and it is important to recognize that the settlement of the Po Valley had not proceeded very far. Population was still massed in central Italy in Latium and Campania, which were undoubtedly more densely peopled than in the early modern period. Such high densities of settlement upon really small areas probably account for the gross exaggerations of the total population of the ancient world common at one time. Similarly, a figure for peninsular Greece has been computed in order to correct the impression that would be derived from the table, which combines peninsular Greece with extensive frontier regions in Macedonia and Epirus.

The general aspect of the map shows that the major portions of the eastern and central Mediterranean littoral were maturely settled. There were important exceptions in the western Mediterranean in what is now Morocco, Spain, southern France, and the Po Valley;

also in Macedonia and Thessaly. Extensive regions were thus open to settlement both in essentially Mediterranean regions and in northwestern Europe. These opportunities resulted in notable changes in the massing of the population of the Empire during the next three centuries, and it is much to be regretted that we have no adequate study of conditions in Roman Gaul for any date in the later Empire.

The figures for the eastern provinces of the Empire present serious difficulties except perhaps in Egypt, for which a fairly good figure is available.[5] It seems clear that the Near East was at least as densely settled as at the close of the nineteenth century; but it is doubtful that the total population of the Near East, as some writers believe, was much greater then than in modern times. Probably the beginning of the Christian era was a period of medium prosperity for the region, and we may perhaps assume that the mass of population was neither the maximum achieved at any time since nor the minimum. In that event there is much essential truth in the conclusion that the population of the Near East and also the Middle East had already become stabilized—ceasing to show any clear growth, though fluctuating somewhat widely around a mean. Such a notion of conditions must obviously not preclude considerable redistributions within the area; notably in Mesopotamia, Persia, and what is now Russian Turkestan and Bukhara.

Western Europe in the Fourteenth Century

After the death of Augustus we find no material for a general study of population in Europe until the first half of the fourteenth century. There are local figures which afford a thin basis for some inferences, but at present there is no material of outstanding significance. For the period immediately preceding the Black Death, in the midcentury, there is fairly good material for England and France.[6] We have a good figure for Brabant in 1374.[7] The other figures are not very adequately supported, though important sections of Italy are well represented. The returns indicate that France had reached a density of population about equal to the modern density. The population in 1340 must have been closely comparable to the population of 1800; and, as growth has been slow during the nineteenth century, the differences are not large even at the present time. The Po Valley had also reached a substantial density of population, though

[5] Beloch's work is notably supplemented by Eugène Cavaignac: Population et capital dans le monde Méditerranéen antique (Publs. Faculté des Lettres de l'Univ. de Strasbourg, fasc. 18), Paris, 1923.

[6] A. P. Usher: An Introduction to the Industrial History of England. Boston, 1920, pp. 92–97.

A. J. C. A. Dureau de la Malle: L'État des paroisses et feux des baillages et sénéchaussées de France (1328), *Bibliothèque de l'École des Chartes*, Vol. 2, 1840–41, p. 170.

Pierre Émile Levasseur: La population française (3 vols., Paris, 1889–1892), Vol. 1, pp. 152–175.

[7] Joseph Cuvelier: Les dénombrements de foyers en Brabant (XIV^{e}–XVI^{e} siècle), Brussels, 1912, pp. ix–xcii.

considerable growth continued to take place in that region. England and Germany were still thinly settled; and, despite vicissitudes, growth was continuing in both areas.

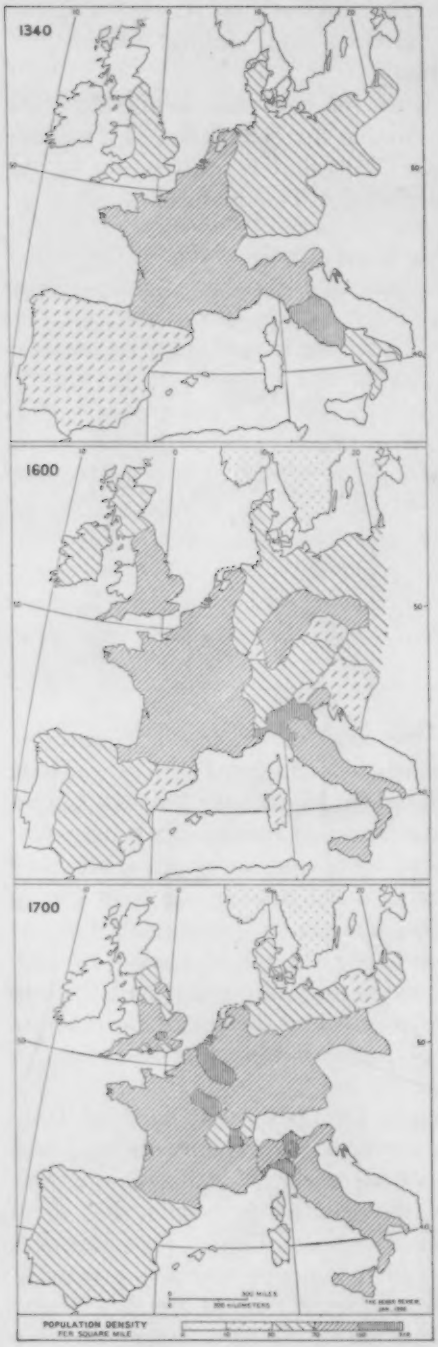
The most important single figure for this date is therefore the figure for France, which definitely marks the completion of a notable stage in the settlement of Europe. Fortunately, this is one of the best documented figures for the period. The material used is an

TABLE II—POPULATION OF WESTERN EUROPE, 1340

COUNTRY	COMPUTED POPULATION	DENSITY PER SQUARE MILE
England	[2,225,000]	43
Germany	.....	[43]
Brabant (1374)	.....	91
France	21,000,000	103
Spain	[6,000,000]	[25]
Catalonia (1378)	450,000	32
Aragon (1404)	250,000	13
Italy	[10,500,000]	...
March of Ancona (*c.* 1325)	.....	151
Romagna (1378)	.....	78
Tuscany (1338)	.....	220
Naples (1447)	.....	52

enumeration of about one-third the area of France in connection with the organization of the expedition against Flanders. These materials were first published in detail by Moreau de Jonnes. Levasseur went over the entire problem with great care, and his judgment was subsequently confirmed by corroborative evidence discovered by Boislisle. Although the material is not a desirable basis for an estimate of the absolute population, the general statement that the density was closely comparable to that of 1800 is hardly open to doubt. We may say, therefore, that the mean density of population in France in 1340 was *about* 100 per square mile. For the broad purposes of a general sketch of the history of population such a statement is wholly adequate.

The figures for Brabant, Aragon, Catalonia, and parts of Italy are for the close of the fourteenth century. It is commonly supposed that the ravages of the Black Death were not offset before the close of the century, so that it is fairly conservative to assume that there was not a large difference between the population of these districts at the two dates. Many writers hold that population was greater in most parts of Europe before the Black Death than at any date thereafter during that century, but this seems to be a rather extreme proposition. Study of the subsidy rolls in England indicates that population was probably smaller in 1340 than in 1377. In countries



FIGS. 2 to 4—Population density of western Europe about 1340, 1600, and 1700 respectively. Compare Tables II, III, and IV.

that were more maturely settled the recovery from losses may not have been as rapid. The inferences drawn by Beloch from available material are given in Table II,[8] as well as the details for portions of Spain and Italy. The relative densities are also shown on Figure 2.

It is unfortunate that the material for Italy is so scanty. Beloch feels fairly certain that the central portions were more densely settled than either the Po Valley or the southern portions of the peninsula. Although the figure for Ancona is almost exactly on the border line between two grades of shading, the map has been shaded on the basis of its inclusion in the upper group. The impression given by the map is probably correct, but this undoubtedly important section is not very adequately documented.

Seventeenth and Eighteenth Century Figures for Western Europe

At the close of the seventeenth century material is more abundant and better in quality. That for England, Italy, Spain, the low countries, and portions of Germany is very good indeed. The figure for France is hardly more than an unsupported contemporary estimate upon an ultraconservative basis. Estimates of a more opti-

[8] Julius Beloch: Die Bevölkerung Europas im Mittelalter, *Zeitschr. für Socialwiss.*, Vol. 3, 1900, pp. 405–423.

TABLE III—POPULATION OF WESTERN EUROPE ABOUT 1600

COUNTRY	AREA (*In sq. km.*)	POPULATION	DENSITY	
			Per sq. km.	*Per sq. m.*
Italy	295,000	13,000,000	44	114
Spain and Portugal	585,000	10,000,000	17	44
France	470,000	16,000,000	34	88
England and Wales	150,000	4,500,000	30	78
Scotland and Ireland	160,000	2,000,000	12.5	32
Netherlands	75,000	3,000,000	40	104
Denmark	40,000	600,000	15	39
Sweden, Norway, Finland	1,080,000	1,400,000	1.3	2.5
Poland and Prussia	210,000	3,000,000	14	36.9
Germany	720,000	20,000,000	28	73
Total	3,785,000	73,500,000		

TABLE IV—POPULATION OF WESTERN EUROPE, 1700

COUNTRY	MODERN AREA (*In sq. m.*)	POPULATION	DENSITY PER SQUARE MILE
United Kingdom	121,600	7,700,000	64
Austria	115,882	16,800,000	70
Hungary	125,609		
Germany	208,054	15,500,000	75
Belgium	11,373	1,550,000	137
Holland	12,648	1,175,000	98
Denmark	15,582	700,000	45
France	207,054	20,000,000	95
Spain	194,783	5,700,000	29
Portugal	35,490	1,575,000	45
Italy	110,550	11,250,000	102
	1,158,625	81,950,000	

mistic type are encountered in contemporary material, but they inspire no confidence. The figure of Froumenteau that is given is consistent with the general impression that France stood at a low level of prosperity at that date. There seems to have been some growth during the seventeenth century, and it is thus reasonable to suppose that in 1600 the population of France stood at one of the minima of the fluctuations that characterize its history since 1300. Beloch's general conclusions are given in Table III,[9] but all the available detail has been used in preparing the map for this date (Fig. 3). Most of the material is taken from Beloch, but the material for Spain is based upon a special study of the materials published by Gonzalez.[10]

[9] *Idem:* Die Bevölkerung Europas zur Zeit der Renaissance, *ibid.*, Vol. 3, 1900, pp. 765–786; reference on p. 783.

[10] [Tomas Gonzalez]: Censo de población de las provincias y partidos de la corona de Castilla en el siglo XVI, Madrid, 1829.

For 1700 the studies of Beloch are supplemented by the work of Dieterici, which is especially important for central Europe.[11] Table IV gives the best estimate that can be made for the larger political areas, but Figure 4 has been prepared from somewhat more detailed statistics for all the primary countries. For Spain no details are available until 1768. It is especially important to note the relative uniformity of the density of population despite the fact that returns have been computed for counties in England, for generalities in France, and for the more important independent states and provinces of Germany and Italy. Before the massive development of mineral resources that characterizes the Industrial Revolution the tendency was clearly towards a relatively uniform density of population over wide areas. The areas of significant concentration were small, and the areas of low density are obviously regions ill adapted to agriculture by reason of one or more deficiencies.

Population Figures for China

Materials for the study of the population of China are more abundant than for Europe or any single European country, and the difficulties of interpretation are not greater. There are problems which for many years led people to presume that the figures were utterly unreliable, but recent studies have provided solutions with adequate documentation. The returns were used as a basis for taxation, and the unit of enumeration has commonly been presumed to be the family. But some enumeration of individuals (mouths) was made as part of the return, and at some periods the return of "mouths" is held to be more trustworthy than that of families. The bias likely to develop from the system of taxation is minimized by the return of both taxable and nontaxable persons. The periods of greatest difficulty are the Sung and early Tsing dynasties (Table V). In the Sung period, the basis of enumeration of "mouths" was changed, and males alone were included.[12] In the early reigns of the Tsing Dynasty only males of military age (16–60) were recorded.[13] When adjustments have been made for these divergences of practice, the series of returns becomes essentially self-consistent and conforms to the expectations created by the history of the country.

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[11] K. F. W. Dieterici: Über die Vermehrung der Bevölkerung in Europa seit dem Ende oder der Mitte des siebenzehnten Jahrhunderts, *Abhandl. Königl. Akad. der Wiss. zu Berlin*, 1850, Phil.-hist. Kl., pp. 73–115.

Häbler, *op. cit.*, Exkurs I.

Julius Beloch: La popolazione d'Italia, nei secoli XVI, XVII e XVIII, *Bull. Inst. Internatl. de Statistique*, Vol. 3, Part I, 1888, pp. 1–42.

[12] Lionel Giles: A Census of Tun-Huang, *T'oung Pao*, Vol. 16, 1915, pp. 468–488.

[13] Chang-heng Chen: Changes in the Growth of China's Population in the Last 182 Years, *Chinese Econ. Journ.*, Vol. 1, 1927, pp. 59–69.

Han Liang Huang: The Land Tax in China, New York, 1918 (Columbia Univ. Studies in Hist., Econ., and Public Law, Vol. 80, No. 3), pp. 96–97.

TABLE V—POPULATION OF CHINA

YEAR	DYNASTY	NUMBERS OF PERSONS (*in millions*)	
		RETURNED IN CENSUS	PROBABLE TOTAL
2	Han	59.5	71.0‖
156	Han	50.0	60.0
606	Lang	46.0	55.0
733	Lang	45.4	54.0
754	Lang	52.9	63.5
1080	Sung	33.3*	79.0
1260	Yuen	53.6	65.0
1290	Yuen	58.8	70.5
1381	Ming	60.5	72.5
1393	Ming	58.6	70.1
1491	Ming	56.0	66.0
1578	Ming	63.5	75.0
1661	Tsing	21.0†	105.0
1690	Tsing	20.3	101.5
1710	Tsing	23.3	116.5
1749	Tsing	177.4	177.4
1780	Tsing	276.6	276.6
1812	Tsing	360.4	360.4
1842	Tsing	413.0	413.0
1860	Tsing	260.0‡	?
1885	Tsing	377.6§	377.6
1923	Tsing	414.0	414.0

*"Mouths" in Sung enumerations refers to males only.

†"Mouths" in early Tsing enumerations refers to males between 16 and 60.

‡This low figure is commonly attributed to the devastations of the Tai Ping rebellion, but the enumeration is probably seriously defective.

§The province of Kansu is included for the first time.

‖Increased by 20 per cent to allow for omissions.

These enumerations include the area that is now comprised in seventeen of the eighteen provinces of China proper. The border province of Kansu was under Chinese control for most of the period, but until the close of the nineteenth century it was administered as part of the dependent territory of Chinese Turkestan, and there are clearly some errors in the figures attributed to this area in the tables.

The record is notable for the relative stability of population at a figure that for this region is really low. Without analysis of details and in the light of the economic history of the times, it would be rash to hazard any conjecture as to the basis of this relative stabilization at less than one-fifth the population capable of being supported in the area without any conspicuous change in the technique of agriculture and industry. It is equally difficult to explain the timing

TABLE VI—ESTIMATED POPULATION OF THE PROVINCES OF CHINA*

(*In thousands*)

PROVINCE	AREA (*In thousands of sq. m.*)	1393	1491	1578	1749	1780	1812	1842	1885	1923
Chili	115.8	.....	[4,130]†	[5,100]	13,933	21,529	27,990	36,879	17,900	34,186
Shansi	81.8	4,890	5,230	6,370	9,509	12,864	14,440	17,056	10,800	11,080
Shantung	55.9	6,330	8,100	6,800	24,011	21,763	28,958	29,529	36,500	30,803
Honan	67.9	2,299	5,230	6,200	12,847	20,275	23,037	29,069	22,100	30,831
Hunen (Hu-) 83.3	154.7	5,640	4,500	5,250	8,672	15,423	18,652	20,048	21,000	28,443
Hupeh (Kuang) 71.4					7,527	16,021	27,370	28,584	33,600	27,167
Shensi	75.2	2,795	4,680	5,410	6,734	8,237	10,207	10,309	3,300	9,465
Szechwan	218.5‖	1,730	3,103	3,720	2,506	7,947	21,435	22,256	71,000	49,782
Kansu‡	125.4	.....	.....	.....	5,709	[15,136]	[15,354]	[19,512]	5,400	5,927
Kiang Su§	38.6	.....	.....	.....	20,972	29,495	37,843	39,646	21,300	33,786
Anhwei§	54.8	[12,900]	[9,560]	[12,520]	21,567	28,085	34,165	36,596	20,600	19,832
Chekiang	36.6	12,520	6,370	6,200	11,877	20,494	26,256	30,437	11,700	22,043
Kiangsi	69.4	10,780	7,820	6,930	8,428	18,049	23,046	26,513	24,500	24,446
Kweichou	67.1	.....	309	348	3,075	5,081	5,288	5,679	7,700	11,114
Fukien	46.3	4,700	3,720	2,062	7,620	11,980	14,779	25,799	23,500	13,157
Kwangtung	100.0	3,602	2,180	6,040	6,460	15,211	19,174	21,152	29,700	37,167
Kwangsi	77.2	1,770	2,020	1,420	3,687	5,749	7,313	8,121	5,100	12,258
Yunnan	146.7	310	150	1,740	1,946	3,201	5,561	5,823	11,700	9,839
Total 17 Provinces**	1,407.0	[70,266]	[67,102]	[76,110]	171,371	261,440	345,514	393,486	372,000	405,399
Total 18 Provinces	1,532.4				177,080	276,576	360,868	413,008	377,400	411,326

*The figures for 1393, 1491, 1578 represent the recorded persons plus 20 per cent; thereafter the recorded persons.
†Part only. Metropolitan district and some outlying areas.
‡Until 1882, part of Sinkiang (Chinese Turkestan). Figures in brackets are probably for the entire province.
§Boundaries somewhat variable.
‖Includes late addition from Tibet.
**Excluding Kansu.

of the rapid growth from the beginning of the Tsing Dynasty, which is in fact closely comparable with the growth of population in England during the period 1750–1900. Relative stabilization since 1840 and the difficulties of interpreting the early Tsing records have obscured the primary features of this notable period of expansion.

TABLE VII—DENSITY OF POPULATION OF THE PROVINCES OF CHINA

(*Per square mile*)

PROVINCE	1393	1578	1749	1780	1812	1842	1923
Chili	..	..	120	187	244	318	295
Shansi	60	78	117	158	177	210	134
Shantung	114	121	435	390	520	530	552
Honan	34	92	188	300	342	430	454
Hunan	36	34	104	185	223	241	341
Hupeh			106	225	387	400	380
Shensi	36	72	89	112	136	137	125
Szechwan*	7.9	17	11	37	98	102	228
Kansu†	..	..	45	[120]	[122]	[156]	47
Kiangsu	..	..	545	765	980	1002	875
Anhwei	[240 +]	[230 +]	392	513	621	670	362
Chekiang	344	170	324	562	715	830	601
Kiangsi	156	100	121	261	334	383	352
Kweichow	...	5	46	76	78	84	167
Fukien	102	44	165	258	318	555	284
Kwangtung	36	60	64	152	191	211	372
Kwangsi	22	18	47	73	95	105	159
Yunnan	2.1	11	13	22	38	40	67
17 Provinces‡	[50]	[54]	122	185	246	274	390

*The Ch'engtu plain, of about 2100 square miles, contains one-tenth of the modern population.

†Until 1882, part of Sinkiang (Chinese Turkestan). Figures in brackets are probably for the entire province.

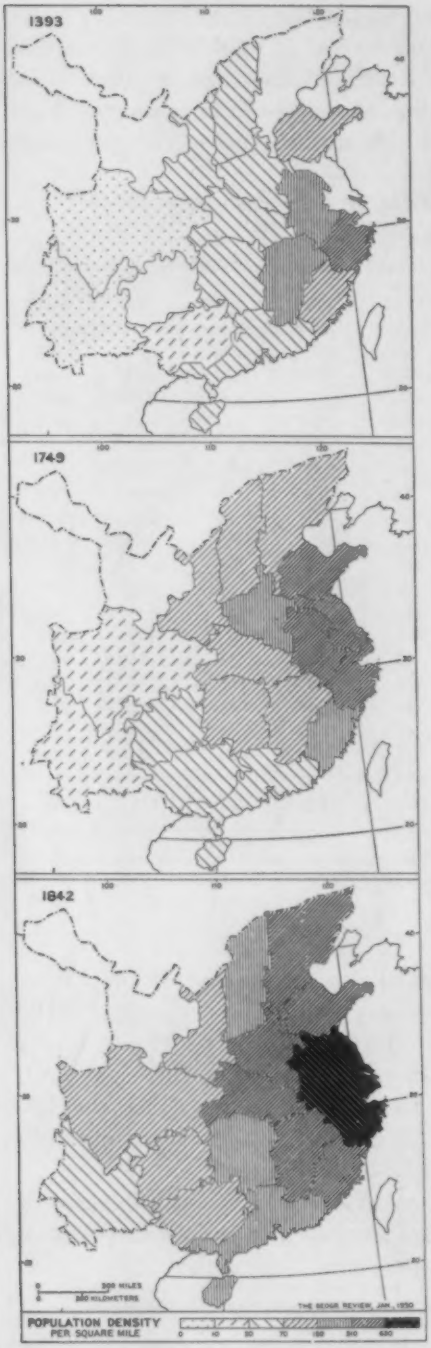
‡Excluding Kansu.

The growth of this period is as difficult to understand as the earlier stabilization, though various factors may readily be suggested. Miss Lee's study of Chinese agriculture[14] discloses a great increase in the cultivated area during the period of rapid growth in the eighteenth century. Table V gives returns for selected years since the full achievement of power by the Han Dynasty, but this represents only a small fraction of the material available in Chinese.[15]

Returns for the provinces are available in European languages from the beginnings of the Ming Dynasty, and, as the administrative geography of China offers serious problems before that date, these

[14] Mabel Ping-hua Lee: The Economic History of China (Columbia Univ. Studies in Hist., Econ. and Public Law, Vol. 99, No. 1), New York, 1921, Table at p. 436.

[15] T. Sacharoff (Zakharov): The Numerical Relations of the Population of China . . . or The Rise and Fall of the Chinese Population, transl. by W. Lobscheid, Hongkong, 1864, pp. 53–54. Many of these data are also given by Miss Lee, *op. cit.* Data for the recent period are taken from The China Year Book, 1926–1927, pp. 2–3.



FIGS. 5 to 7—Population density of China by provinces in 1393, 1749, and 1842 respectively. Compare Tables VI and VII.

returns afford whatever data are easily available at present, irrespective of linguistic problems. The statistical material is given in Tables VI and VII.[16] The significance of the data, however, will be most readily seen in the series of maps (Figs. 5, 6, 7). The provinces of the southwest present many palpable elements of frontier conditions, though in part at least they had long been settled. The general densities of the great central plain are also surprisingly low, so low that one must presume the existence of substantial areas that were not taken effectively into cultivation. The areas of the provinces are relatively large, and few of them are really homogeneous. The provincial figures are therefore scarcely adequate to afford a complete description of the characteristic features of settlement. Have we to do with localized concentrations at relatively high densities or a widely diffused population at the low densities indicated for the total area of each province? One is inclined to believe that the former type of settlement is the more common; but there is really no certainty. It is evident from travelers' accounts and from modern studies that general provincial figures are hardly significant for the large province of Szechwan on the frontier of

[16] W. W. Rockhill: An Inquiry into the Population of China, *Ann. Rept. Smithsonian Instn. for 1904*, p. 662.

T. Sacharoff, *op. cit.*, p. 55.

The China Year Book 1926–1927, p. 3.

Some additions have been made to the earlier figures.

Tibet. Part of the province is mountainous and unfertile, but the Ch'eng-tu plain carries today a population of extraordinary density. We may be certain that the character of agricultural occupation of this great plain is of considerable antiquity. Followed out with care, the case of this province might lead to an explanation of much that is now obscure in the history of the population of China.

The uncertainties present in estimates of the population of China since 1885 illustrate perfectly the inadequacy of material of this character for studies of population over short periods of time. The probable error exceeds by a large measure any possible increase per year or even per decade, so that for such purposes the returns cease to have any serious value. We are really unable to feel much conviction about details after 1842. The figure for that year may be too large, but census work was more careful than at the close of the century. Professor Walter F. Willcox presents strong arguments in favor of the position that the population of China has not exceeded 320,000,000, either in the midnineteenth century or in recent years. His most recent discussion of the problem will appear in the second volume of Migration Statistics to be issued by the National Research Council.[17] It is not intended to call these conclusions in question, but in view of the uncertainties of the data it seemed best to adopt the maximum possible estimate throughout the tables for China. In the present article only the general trend is emphasized together with the broader contrasts between the more and less densely settled provinces.

The Middle East

The term Middle East is sometimes applied to the entire region east of Syria and Armenia to the borders of India and eastern Turkestan. Despite the importance of this region in the early Christian era and during the Middle Ages, we have no statistical information about the population. Conditions in the Middle East are of the utmost importance in any concepts we may form of the general history of settlement, and consequently before entering upon that phase of our subject some attention must be given to the problems of this area.

The vagueness of information has given rise to wide divergences of opinion extending down to the present time, because no enumerations have been made in the area even in recent years. We know from historical sources that the latter nineteenth century was not a period of great prosperity: for various reasons, economic and political, general conditions must be regarded as distinctly less favorable than at various times in the past. The descriptions in the writings of the Arab geographers indicate clearly that the tenth century was the

[17] See also his paper "The Population of China in 1910," *Bull. Inst. Internatl. de Statistique*, Vol. 23, Part II, 1928, pp. 347–361, and *Journ. Amer. Statist. Assn.*, Vol. 23, 1928, pp. 18–30.

period of greatest prosperity during the Caliphate, and later historians indicate the sixteenth and seventeenth centuries as periods of prosperity in Persia.

We have also the means of establishing the dates of the primary changes in the rivers and irrigation works in Mesopotamia. The first break with the hydrographic system of antiquity occurred as the result of floods in the fifth century of the Christian era. The Tigris overflowed its banks in its lower course and joined the Euphrates in forming a swamp above Basra. This damage was partially repaired, but greater floods in 629 A. D. opened up the new channel again, and the Great Swamp became a permanent feature of the basin. Its extent was perhaps somewhat diminished when the Tigris returned to its older course early in the sixteenth century. These changes reduced the cultivated area of the lower basin both by the enforced abandonment of the land on the old course of the Tigris and by the flooding of a considerable area between Basra and Kufa. At the close of the twelfth century there were further losses through the silting up of the Nahrawan canal, east of Baghdad.[18] This great irrigation work became a complete ruin in the course of the next century, partly through neglect, partly because of changes in the régime of the river that increased the difficulty of maintaining the works. In Mesopotamia economic conditions must have been relatively less favorable after the seventh century; but these local difficulties did not prevent the region as a whole from attaining notable prosperity in the tenth century.

The general features of the economic development of these regions of the Middle East were fixed at an early date. Settled agriculture was restricted to the river valleys, and the larger areas were dependent upon some measure of irrigation. Rainfall was supplemented by using the underground seepage from the mountains.[19] The outstanding features of this general system were definitely established long before the beginning of the Christian era, but we have no means of knowing the area to which this technique was applied. Some writers assume that Persia had a population of fifty millions in the time of Darius; even if we disregard the question of numbers, this is certainly the earliest date that can be given for a full settlement of the region, and it would be more conservative to assume that the full settlement of the region did not take place until later, either under the Selucid Dynasty (311–129 B. C.), or at the latest under the Sassanid Dynasty (229–628 A. D.). We may assume, then, that while there have been fluctuations there has been no real growth of population in this area since the early part of the Christian era or perhaps earlier.

The Middle East undoubtedly presents special features in respect

[18] Guy Le Strange: The Lands of the Eastern Caliphate, Cambridge, 1905, pp. 25–30.
[19] Compare "Irrigation Systems of Persia," by C. B. Fisher, *Geogr. Rev.*, Vol. 18, 1928, pp. 302–306.

to the distribution of the population over the total area. The major portion is concentrated in relatively large towns, surrounded by villages of considerable size. The village population lives under conditions sensibly different from the dispersed rural population of the north temperate zone, and the proportion of the population living under positively urban conditions is high. According to General A. H. Schindler the population of Persia in 1884 was distributed as follows:[20]

	Persons	Per Cent
99 towns	1,963,800	25.6
Villages	3,780,000	49.5
Nomads	1,909,800	24.9
	7,653,600	100.0

These totals are possibly somewhat low, but the proportions are suggestive of the profound differences in the type of settlement. Such a proportion of urban population was not achieved in Europe until the railroad had exerted a significant influence upon the distribution of the population. The town was the basic feature of social life in the Near and Middle East. The characteristic features may be studied in the large-scale maps of Bukhara and Samarkand. The general appearance of these districts must be much as it was in the tenth century when described by the Arab geographers. These high concentrations on relatively small areas are likely to lead us to overestimate the total population. It would probably be possible to prepare significant maps of settlement for the period of the Caliphate as the habitable areas can be tolerably well identified in the Arabic sources.

The Problem in India

India presents a very difficult problem, but recent studies by W. H. Moreland[21] throw much light upon conditions during the sixteenth century. Analysis of the military forces put in the field in the south in 1522 leads to the conclusion that the south contained about one-half the population of 1911—in all about 30 millions. For the important region of the valley of the Ganges no means exists for a direct estimate of numbers of persons, but during the reign of Akbar accounts of the cultivated area were gathered which yield important results to careful study. In the northwestern portion of the United Provinces and in the eastern section of the Punjab the cultivated area amounted to about three-fourths the standard of 1911. This stretch extended from Lahore to Agra, including especially the region between the Ganges and the Jumna. Easterly from Agra

[20] George N. Curzon: Persia and the Persian Question (2 vols., London, 1892), Vol. 2, p. 493.
[21] W. H. Moreland: India at the Death of Akbar: An Economic Study, London, 1920, pp. 16–22.

the standard of cultivation declined steadily until at Allahabad the proportion fell to about one-fifth the standard of 1911. This low standard of cultivation continued thence down the valley almost through Bihar. Bengal is known to have been populous, but we have no record of the relative density; and lack of data makes it similarly impossible to form any estimate for Gujarat. These inferences are expressed in graphic form in Figure 8. The practical identity of agricultural methods makes it possible to draw inferences about population from these records of the cultivated area. Moreland concludes:

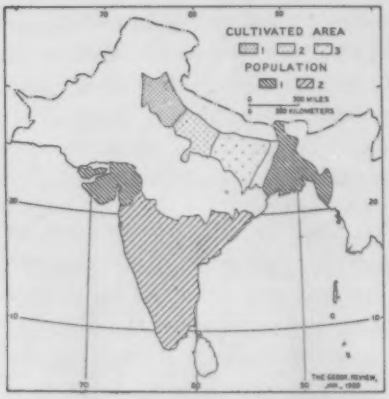


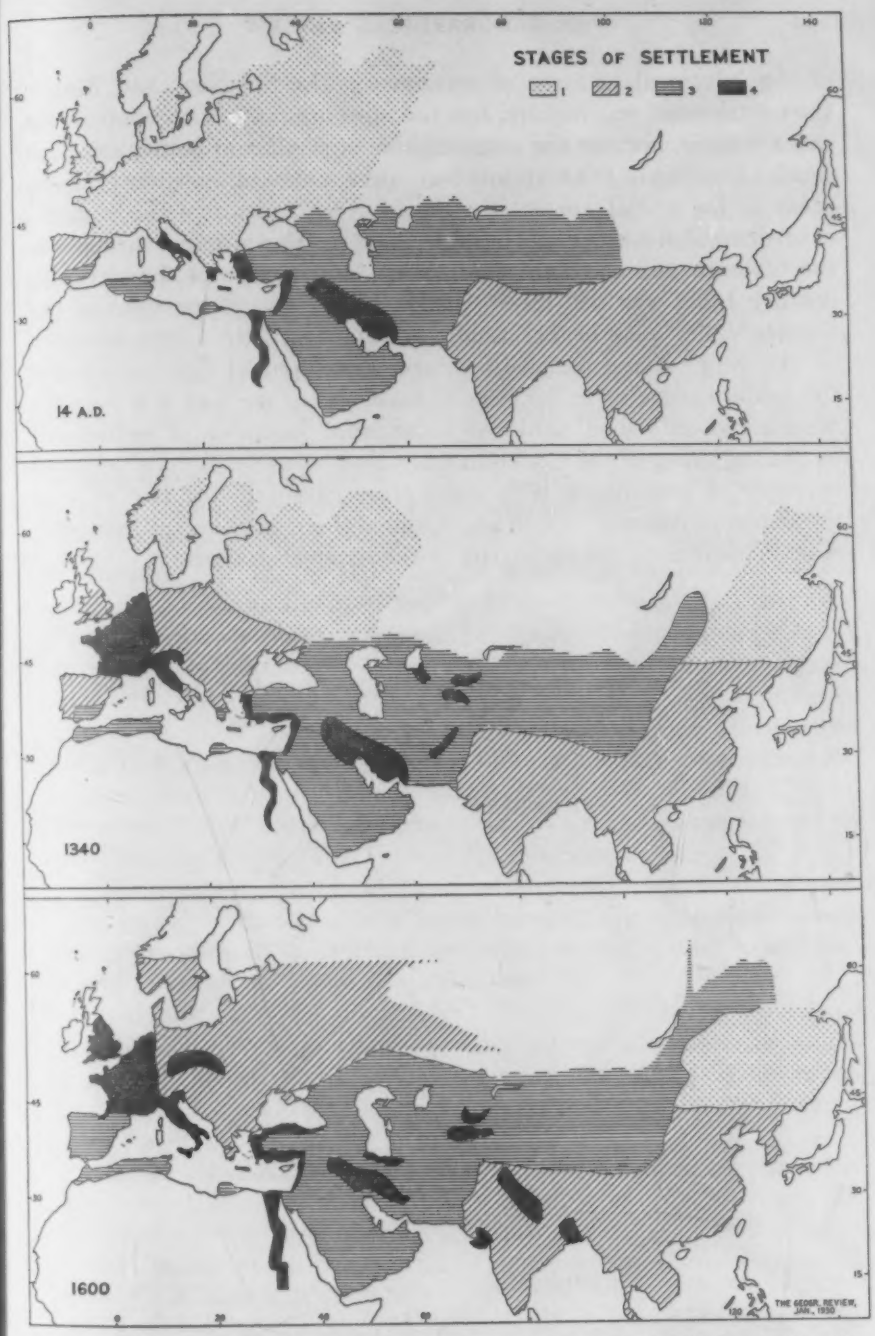
FIG. 8—India in the sixteenth century. Stipple shows extent of area cultivated in 1600 in relation to modern area: 1, over 75 per cent; 2, 20 to 75 per cent; 3, less than 20 per cent. Ruling shows: 1, populous areas of unknown density; 2, area with 50 per cent of population of 1911.

> If now we apply these conclusions to the figures of the last census, we shall find that the population of the northern plains from Multan to Monghyr must have been well over 30 millions and probably little less than 40 millions at the period to which the statistics relate. We have thus a total of at any rate more than 60 millions in sight for the northern and southern areas taken together, but without allowing anything for two populous regions, Bengal and Gugarat, or for any part of the more sparsely populated but extensive intervening area; and, when we bring these excluded tracts into account, we are justified in concluding that there must have been at the least somewhere about 100 millions of people in India in order to carry on the activities disclosed by contemporary authorities. The number is absolutely very great and would have appeared almost incredible to European observers of the period, but it is only one-third of what the same area contained in the year 1911; various arguments could be adduced for a higher figure, but the nature of the data compels us to be content with indefinite estimates, and it appears to me that we shall run no risk of serious error if we take 100 millions as indicating a total, not indeed attained by careful enumeration but rendered probable by a consideration of all the relevant facts which are available.

MAPS OF SETTLEMENT STAGES

Although many problems demand further investigation and more extended critical discussion than is possible in this paper, it has seemed desirable to prepare a series of maps which represent concretely a conservative view of the stages of settlement at the three critical dates 14 A. D., 1340, and 1600 (Figs. 9–11).

The general features of these maps are obvious. None of the centers of massive modern population was maturely settled at the beginning of the Christian era. Northwestern Europe may be confidently classed as a frontier. India and China were in early phases



FIGS. 9 to 11—Stages of settlement in Eurasia about the beginning of the Christian era, the mid-fourteenth century, and the beginning of the seventeenth century respectively. The numbers have reference: 1, frontier regions; 2, regions at intermediate stage of settlement; 3, maturely settled regions with low densities of population; 4, maturely settled regions with high densities of population.

of the intermediate stage of settlement. In the Near and Middle East settlement was mature, but the absolute mass of the population was not large, because the areas capable of significant settlement were small. Shading of the map involves, almost inevitably, some exaggeration of the actual areas. By the fourteenth century the progress of settlement in Europe was notable, and growth continued throughout the fifteenth and sixteenth centuries. At the close of the sixteenth century India was still incompletely settled, though portions of the Ganges Valley were beyond doubt maturely settled. China was only on the verge of the period of notable development that established the modern patterns in her density map. Thus we may say that the Mediterranean region achieved substantial maturity of settlement by the beginning of the Christian era. Northwestern Europe achieved maturity of settlement, with some areas excepted, by the close of the sixteenth century. India and China did not achieve full maturity of settlement until the early part of the nineteenth century.

VARIATION IN LAKE HURON LEVELS AND THE CHICAGO DRAINAGE CANAL

Mark Jefferson

IN mid-July, 1929, the ferrymen at St. Clair, Mich., were complaining of the very high stage of the St. Clair River—three and a half feet above the usual stand. This would be little on the turbid Mississippi or Ohio, which may easily go up twenty or thirty feet in a single rain (Fig. 1).

The stability of the outlets of large lakes is really a natural accompaniment of the beautiful clear blue waters. The waters are clear because the lake has served them as a settling basin in which all sediment has dropped. Their level is stable because of the great area over which rain waters must spread out. Lakes Michigan and Huron—really one lake at one level—have a surface together of 46,000 square miles. No single storm ever poured out water enough in that basin to raise the water level significantly. The level rises and falls in the course of a year only a little over a foot, and so structures along the St. Clair River have never made much allowance for flood conditions. The present high water has submerged docks and cement steps to boats, causing considerable expense for rebuilding.

"The Chicago Drainage Canal is shut off," the ferrymen said. "The people of the other lake states brought suit against them and made them close it!"[1] Nothing that could be said would make them believe the Sanitary Canal was still open.

No doubt about the high water. Seventeen miles east of Sarnia is Kettle Point, Ontario, where great three-foot balls of iron carbonate in the cliffs used to stand well above a foreshore of flat-lying ledges. Now the foreshore ledges are under water and the "Kettles" awash in the waves.

The beaches north of Port Huron have been spoiled by the rise of Lake Huron, bringing the waves into play on shrubs, grass, and dirt that were recently well above water and replacing a hundred miles of clean, sandy shore by mud and rubbish in the water that makes bathing well-nigh impossible.

What could be the cause of the unusual high water? Though the summer has been dry, the spring had been unusually wet at Detroit. Had there been excessive rain for several years?

On looking the matter up I find that this has been actually the case.

[1] On this question see Philip W. Henry: The Great Lakes-St. Lawrence Waterway, *Geogr. Rev.*, Vol. 17, 1927, pp. 258–277.

This is the fourth year in which rain has been in excess of normal in the basin of Lake Michigan, while the three years just preceding them were all short of water. Both groups of years, the present wet ones and the preceding dry ones, had very distinct effect on the lake levels.

The Weather Bureau has over a hundred stations in the state of Michigan where rainfall is measured. The average catch of these stations affords a very fair idea of the precipitation on the basin. For a long series of years this average has ranged around 30.8 inches a year. Last year it was 33.3 inches; in 1927, 31.5; in 1926, 33—all greater than normal. But in the years just before these it was 25.5, 29.8, and 28.8. There was an accumulated shortage of rain from the normal for those three years of 8.3 inches. Since then, up to the end of May, 1929, there has been an accumulated excess of 9.3 inches. Naturally the lakes have been high. The period of excess ended early in the summer, and a period of deficient rain set in. At the time of writing—November 5—the accumulated excess has probably disappeared, and the lake has fallen two feet from its high level of July.

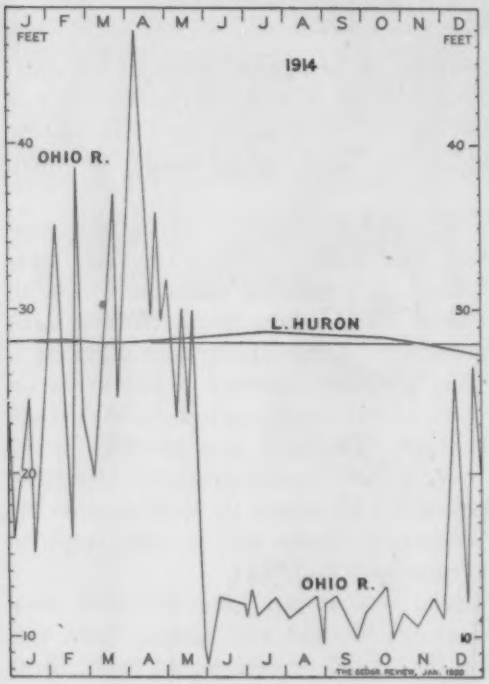


FIG. 1—Fluctuations of Ohio River and Lake Huron for 1914 on the same scale. Lake Huron is about a foot higher in summer than in winter. The Ohio River is about forty feet higher in spring than in summer.

But what, as a matter of fact, have been the lake levels through these years? They are found on a great hydrograph published by the United States Lake Survey and obtainable at its offices in the lake cities.[2] It gives on one diagram curves of the fluctuation of all five lakes from 1860 to the present time. It shows at once that the lakes were falling to a very low level in 1923, 1924, and 1925 and since then have been rising, just as the rainfall would lead one to expect. The levels are given in feet above mean sea level. The Huron gauge is at Harbor Beach on the Thumb of Michigan. The Milwaukee gauge has substantially the same readings. The water fell pretty steadily

[2] For a reproduction of this hydrograph for the period from 1860 to 1925 see Philip W. Henry, *op. cit.*, Fig. 3, pp. 266–267.

through 1922, 1923, 1924, and 1925 and reached its lowest point in the beginning of 1926. Since that time it has been rising steadily. In 1929 it rose especially rapidly, reaching 582.1 feet in May and 582.3 feet in June and July—higher than it has been in forty years. At the end of October it had fallen to 581.14 feet.

All the lakes rise and fall together. They all went down from 1922 to 1926, and they have all been rising since. Except for minor irregularities this seems to have been the case always. The high water of record (1838) was high for all the lakes—Superior 605.3 feet, Michigan-Huron 584.7, Erie 575.1, and Ontario 249. Erie has not been so high as it was this year since 1876, nor Ontario since 1908. Superior was higher in November, 1928, than it has been since 1916.

When these risings and fallings are studied on the hydrograph they are found to be complicated by a regular annual oscillation of the lake surfaces between a winter low water and summer high water. Huron-Michigan, for instance, is regularly about a foot higher every August than in February. The low water comes as surely as winter itself.

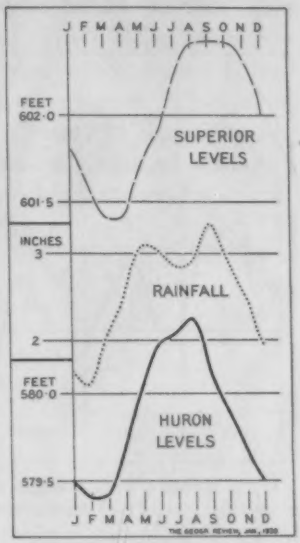


FIG. 2—Average monthly water levels of Lake Michigan-Huron (solid line) and Lake Superior (broken line) for the period 1909–1928 and the average monthly precipitation of the state of Michigan (dotted line) for the same period.

That the annual oscillation of the lake reflects the variation of the rainfall through the year cannot be doubted when the two curves of Figure 2 are compared. The lakes are low in winter because there is little rain in winter; they are high in summer because summer is the main season for rain—nearly nine inches in May, June, and July to five in December, January, and February. The five lakes agree in their annual oscillation because they are governed by the rainfall in their basin.

The rainfall for Michigan as a whole agrees very well with the curve for Lake Huron because its area corresponds well with the area of the basin. For Erie, Ontario, or Superior we should need some additional rain-measuring stations to correspond better to their catchment basins. But from the general agreement of the hydrographic curves for all the lakes we may be sure the figures would not be very different for the other lake basins.

Evaporation must lower the lake levels in summer. Every new or enlarged outlet of the lakes must lower the water level. But the lakes are regularly high in summer when the evaporation is greatest; and the

lakes are unusually high just now when a number of old channels have been deepened and a number of new openings made. Hence none of these things is dominant. The one dominant thing that governs the height of the water is the rainfall of the season, though the rain of single storms is unable to affect it appreciably.

The engineers of the Chicago Sanitary Commission estimate that the Drainage Canal may lower Lake Michigan-Huron from six to eight inches. If that happened at a time when the rainfall was scanty

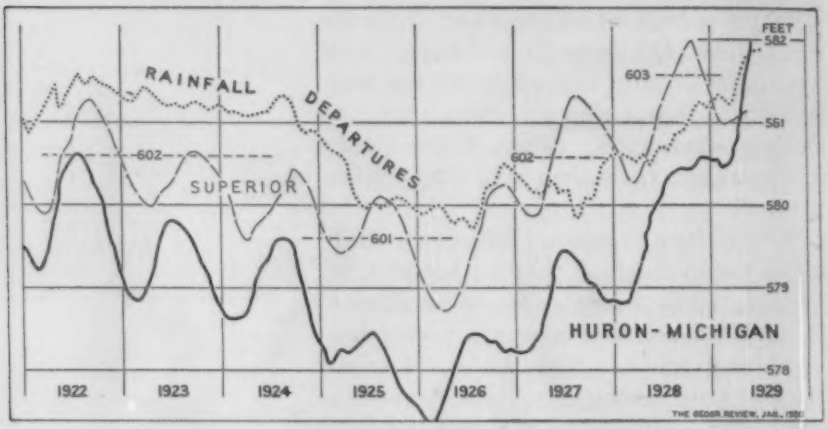


FIG. 3—Levels of Lake Michigan-Huron (solid line) and of Lake Superior (broken line) from 1922 to 1929 and (dotted line) departures of the rainfall from normal.

for several years, it would aggravate a condition of low water already serious. The beginning of 1926 was such a time. Outcry against Chicago's diversion of lake waters was at that time inevitable. But there is little doubt that if the canal could have been closed the complainants would have been disappointed at the smallness of the result. The lake was down to 577 feet 5 inches. Closure of the canal might conceivably have raised the level to 578 feet—still a stage lower than had ever been recorded. The lake has not been even within a foot of that level since 1896. It is noted that Lake Superior, which cannot possibly be affected by the Chicago Drainage Canal, was lower in the beginning of 1926 than at any time in the record. Only twice in the last sixty years has it been within a foot of that stage.

Fifty years ago Lakes Michigan and Huron were usually a good two feet higher than they have been in the last twenty years. That is not true of the other lakes. No doubt the deepening of the outlet channels as well as the opening of the Chicago Drainage Canal have tended to bring this about, yet if all the channels could be restored to their condition in 1860, the year 1926 would still have been one of inconveniently low water. The deficient rainfall of the three preceding years was bound to have that result.

The line of rainfall departures on Figure 3 goes up with rain for a month in excess of the normal for that month and down with rain in deficiency of the normal, and goes up or down by the extent of the departure. Lake Huron levels behave in close sympathy with this curve of rainfall departures because it determines them.

At the present time so much water has fallen in the lakes basin that every outlet affords relief from too high water. If it were not for the Chicago Drainage Canal the water would be somewhat higher than it is. But heavy rainfall is exceptional. The Chicago Sanitary Commission probably tends to use more and more water rather steadily as the city to be served increases in population. The variations of rainfall in the region make this very acceptable for years that are wetter than usual but nearly intolerable in years of drought. Changes in the city's needs do not correspond with changes in the supply of water.

SURVEYS IN HISPANIC AMERICA

NOTES ON A NEW MAP SHOWING THE EXTENT AND CHARACTER OF SURVEYS IN HISPANIC AMERICA

Raye R. Platt

[With separate map, Pl. II, facing p. 142]

WITH the compilation of approximately two-thirds of the American Geographical Society's Millionth Map of Hispanic America completed and the assembling of source material for the remaining sheets rapidly nearing completion, it is now possible to construct a "reliability map" showing the extent and character of existing surveys for the whole of Hispanic America that, except in a few limited areas, is of a high degree of accuracy.

Cartographic History

The mapping of Hispanic America has passed through two distinct periods and is now well advanced in a third period. These three periods may be characterized as (1) the colonial, (2) the period of reconnaissance surveys, and (3) what may be termed the period of national consciousness and economic development.

In the first period—the period of discoveries, conquests, and colonization dating from the Discovery up to the early years of the nineteenth century—the broad outlines of the continent gradually took form as notes and sketches; and, finally, fairly accurate surveys tied to astronomically located positions accumulated and were compiled into maps of steadily increasing range, detail, and accuracy. On the mainland, where, except in the Guianas, British Honduras, and the Misskito Coast, the sovereignty of the original conquerors was never effectively contested, the source material was supplied almost exclusively by Spanish and Portuguese conquerors, navigators, administrators, ecclesiastics, and adventurers. For the West Indies, however, where for nearly 300 years the sovereignty of the various islands was a matter of almost constant conflict and change, British, Dutch, and French navigators and cartographers made the most important contributions to the cartographic material that had accumulated by the end of the eighteenth century. Little in the way of original surveys has come down to us from this period. Our knowledge of the work done comes to us mainly from the remarkable compiled maps and atlases of the period.

The second period in the development of Hispanic American cartography may be said to date from the journeys of Alexander von Humboldt just previous to the outbreak of the revolt of the Spanish colonies. It may be termed the period of reconnaissance surveys, because it is chiefly characterized by the explorations of European scientists and travelers who, while only in exceptional cases employing precise methods of survey, produced thousands of miles of route and river traverse the greater part of which has never been replaced by later or more accurate surveys. Particularly for the majority of the tributaries of the Amazon River compilers of maps of Hispanic America must still use the reconnaissance surveys of this period. To this period also belongs that remarkable series of general maps produced for the governments of the Caribbean and West Coast republics by European cartographers who identified themselves with some particular country, made its cartography their life work, and left behind them maps that are lasting monuments to

their devotion and skill. Codazzi's maps of Venezuela and Colombia, Pissis' map of Chile, Raimondi's map of Peru, and Wolf's map of Ecuador are outstanding examples. No article on the cartography of Hispanic America is complete without reference to these men. They covered hundreds of square miles of difficult trail, making rapid surveys, establishing astronomical positions, determining barometric altitudes, collecting information from every available source for areas they could not visit personally, and eventually producing maps that in quality of compilation and reproduction and in intelligent selection of details are models of their kind. No map of the east coast countries compiled during the same period compares with them. They are the "mother maps" of all compiled maps that have since been produced of the countries they cover. Naturally they vary greatly in accuracy in different sections. They are remarkably accurate, considering the rapid methods employed, in those areas which the compilers surveyed themselves. They are of varying degrees of accuracy where the compilers had to depend on information of varying degrees of reliability. In Chile the Pissis map has been replaced by the map on the scale of 1:500,000 compiled and published between 1904 and 1908 by the Oficina de Mensura de Tierras. In Colombia the Oficina de Longitudes has produced new maps of several of the states in uniform style on the scale of 1:500,000, based on many new determinations of latitude and longitude and containing much new reconnaissance work but still depending to a considerable extent on Codazzi's map. In Ecuador and Peru many attempts have been made to substitute new compilations for the Wolf and Raimondi maps; but, although the products of these attempts contain new material in certain areas, they are far inferior to the older maps in general accuracy and in quality of compilation and reproduction.

There is no clearly defined line of demarcation between the second period in Hispanic American cartography and the third. The length of the second period varied in the different countries. Its close coincides approximately with the achievement in the various countries of a measure of stability in government after the long period of civil wars and sporadic insurrections that, in most of the countries, followed the establishment of the republics, and the resultant possibility of at last devoting a part of the resources of the countries to their economic development. The entrance of the third period by no means closed the period of reconnaissance surveys for purely scientific purposes. Such surveys are still in progress and differ from earlier surveys of the sort only in that they are in general carried out by more precise methods. But in quality and extent they are now quite outweighed by surveys conducted for the exploitation of the natural resources of the various countries, surveys for transportation and communication routes, surveys for the location and demarcation of international boundaries. The programs of topographic survey now instituted in many of the countries have for their purpose the systematic examination of natural resources; but progress on them, as has been said, is slow. The chief source of new and accurate surveys of extensive areas is found in the surveys that have been made, particularly during the last fifteen years, by development companies, mainly supported by foreign capital. In the Caribbean area, and particularly in Colombia and Venezuela, the surveys made by petroleum companies during this period have, in quality and extent, exceeded all others made in Hispanic America during the same period.

The Reliability Map

The sheets of the Millionth Map now completed or in an advanced state of compilation cover all of the Pacific coast and Andean region of South America, all of Patagonia, the northern part of South America as far east as the mouth of the Amazon River together with practically the whole of the Amazon Basin, the countries of Central America, the West Indies, and parts of Mexico. Within these areas the

general reliability map, Plate II, has been constructed directly from the reliability maps that appear on each sheet of the Millionth Map. Outside these areas it has been constructed from original surveys assembled for compilation, supplemented in those areas for which the collection of source materials is not entirely complete by approximate details taken from the most reliable compiled maps and based in most cases on actual information as to surveys completed.

The map is not to be taken as a complete index to all the surveys that have been made in Hispanic America. Rather, it is, with the few exceptions mentioned above, an index to the surveys that are, in some form, now available. In other words, it is an index of the collection of source material assembled to date for compilation into the Society's Millionth Map. When this collection is complete the map will require modification. It is certain, however, that modification will be a matter of minor details only. The greatest amount of change will occur in northeastern Brazil. On account of the long-standing and advanced state of settlement, it is assumed that a certain amount of survey work has been done here although we have had neither access to copies of the original work nor precise information concerning it. The extent and character of these assumed surveys have been based on compiled maps and a thorough study of the character of the areas in which they have been plotted and the type and extent of economic development there. Mexico will probably rank second as regards change although there the large area shown as covered by surveys of the third class (reliable traverses) is covered by so close a network of reconnaissances and traverses for railway routes and roads, river traverses, and surveys of mining and petroleum regions that it is doubtful if any changes will be apparent on a map of this scale. The case of the Argentine pampa is similar. There the network of railway and road traverses and cadastral surveys is so close that it is probable that they can only be shown as covering a broad area as indicated on the map.

The surveys have been classified on the reliability map in five groups:

1. Triangulation with precise topographic survey.
2. Triangulation with approximate topography from plane-table sketches and traverses.
3. Reliable traverses.
4. Approximate traverses and compass stretches.
5. Triangulation without other surveys.

The areas covered by surveys of the first, second, and fifth type are shown in true scale as are the third and fourth in the broader areas. Where these latter, however, consist of route and river traverses the width of the area covered by the traverse has been exaggerated for legibility.

The first group consists mainly of the work so far completed on the programs of systematic topographic survey on which certain of the Hispanic American governments are now engaged. To this have been added in Colombia certain surveys made for the examination and exploitation of mineral and petroleum areas. In Peru there have been added, in the vicinity of Lima, a number of irrigation surveys as well as two large areas in the southeastern part of the republic, the more westerly of which is made up of the survey of the Içа Valley for irrigation purposes and a large area to the north of it surveyed for the study of railway routes, while the more easterly covers the surveys of the Yale University and National Geographic Society's expeditions of 1911 and 1913.

Although the surveys included in the first group are described as precise topographic surveys, it is probable, however, that the only surveys shown on the map that actually rank with the highest type of topographic survey as carried out in Europe and the United States are those shown in the eastern part of the Argentine Republic and conducted by the Instituto Geográfico Militar of the Argentine Army, the small area shown in Uruguay, and a few very limited areas in Chile. The greater

part of the surveys classified in this group, although based on good triangulation, are composed of the more rapid types of topographic survey. In the surveys made by the Argentine Dirección de Minas, Geología e Hidrología in the western part of the Argentine Republic they include topographic detail obtained by the use of stereoscopic photography. For the sheets of the Carta Nacional of Peru on the scale of 1:200,000, on which considerable progress has been made in the northwestern part of the republic, aerial mapping has recently been introduced to some extent. Perhaps the most striking feature of the map is the limited area covered by surveys of this group. On the other hand it is due to the fact that so many of the Hispanic American governments are committed to programs of surveys of this type that more progress has not been made on the less accurate types of survey which are much more in accordance with the needs of countries that are still largely in the pioneer state. The Argentine Republic, Chile, and Colombia have adopted for their military maps the scale of 1:25,000, and, because of the great expense involved, progress on them has been slow. On the other hand the scale of 1:200,000 has been adopted by the Argentine Dirección de Minas, Geología e Hidrología and the Servicio Geográfico of the Peruvian army, and the scale of 1:100,000 by the Geological Survey of the Brazilian state of São Paulo, with the result that these organizations have been able at moderate expense and satisfactory speed to cover large and economically important areas with surveys that completely satisfy the need.

The second group includes topographic reconnaissances by various approximate methods based on good triangulation. Although only in rare instances do these surveys include contouring of any sort, they do include a sufficiently large number of spot heights to make it possible to construct contours that on the scale of 1:1,000,000 closely approach the results of an actual contoured survey. The most extensive area covered by surveys of this type is the Chile-Argentine boundary zone, of which the best available surveys are those made by the Chilean Comisión de Límites. There triangulation in its precise sense was not employed, but a system of polygons was substituted for it.[1]

The third group includes reconnaissances and traverses made by a great variety of methods but in all cases based on stadia, theodolite, or plane-table traverses tied in most cases to accurately determined astronomical positions. In it are included railway and road traverses, the more precise railway and road reconnaissances, and route and river traverses as well as plane-table and theodolite reconnaissances of mining and petroleum areas. The broad area indicated in Mexico as made up of surveys of this type includes, in addition to railway and road surveys and the surveys conducted by mining and petroleum companies, the very extensive route and river traverses made for incorporation in the 1:100,000 map of Mexico. In detail the surveys of this group vary from contoured surveys like that of the Intercontinental Railway survey of the early 90's and many highly detailed reconnaissances of mineral and petroleum areas to river and route traverses on which the only indication of topography is by means of spot heights and hachures or hill shading.

The fourth group is made up of the less reliable route sketches. Such surveys vary greatly in accuracy according to the skill of the sketcher, the nature of the terrain, and the purpose of the sketch. They may be considerably detailed or mere diagrammatic sketches. They are apt to vary greatly in scale from point to point and usually require much adjustment. Yet they constitute a large part of our cartographic information on Hispanic America.

The fifth group consists of precise triangulation made for geodetic measurements and unaccompanied by topographic surveys. The most famous of these is the Measure of the Arc of the Meridian of Quito conducted from 1899 to 1906 by a

[1] See Prof. A. Bertrand: Methods of Survey Employed by the Chilean Boundary Commissions in the Cordillera of the Andes, *Geogr. Journ.*, Vol. 16, 1900, pp. 329–345.

mission of the Service Géographique of the French Army under the auspices of the French Academy of Sciences. In Mexico the geodetic work of this type shown on the map is the beginning of a system of triangulation tied in to that of the United States which will eventually cover the whole republic. In the Argentine Republic it is being carried out as the basis for the military map on the scale of 1:25,000.

The Catalogue of Maps of Hispanic America

In spite of the lack of topographic surveys of high grade as shown by the map accompanying this note, it is nevertheless clear that Hispanic America is by no means a *terra incognita*. Thousands of miles have been traversed by more or less accurate methods, and hundreds of square miles covered by various types of topographic survey. But these surveys are widely scattered. They are to be found to some extent in scientific periodicals and books. In sheet map and atlas form they exist in many widely scattered collections. A great part of them, however, are to be found only in the confidential archives of the various Hispanic American governments and of foreign and domestic development companies. For the published maps, widely scattered as they are through numerous libraries and collections, a general catalogue is needed if they are to be generally accessible to students of Hispanic America. In order that the unpublished and in large part confidential surveys may be made accessible it is necessary that they be compiled into a general map on a sufficiently large scale for actual use. The latter need will be supplied by the Society's Millionth Map of Hispanic America. For the former the Society has now completed the compilation of the catalogue of maps of Hispanic America on which it has been working for the past seven years.

The catalogue has been compiled from the published maps contained in the library of the American Geographical Society, the New York Public Library, the Library of Congress, the library of the Pan American Union, and the libraries of Harvard, Yale, and Columbia universities. The catalogue is a selected and classified list of over 15,000 items. It will be published by countries in four volumes, the map list for each country being divided into five sections: (I) Maps in Scientific Periodicals, (II) Maps in Books, (III) Sheet and Atlas Maps (Official Publications), (IV) Sheet and Atlas Maps (Unofficial Publications), (V) Historical Maps. Articles on the cartography of the various countries with reliability diagrams on a larger scale than the general map presented here will accompany the map lists. The catalogue is now being set in page proof, and it is expected that it will be ready for distribution in the spring.

MAP OF
HISPANIC AMERICA
SHOWING EXTENT AND CHARACTER OF EXISTING SURVEYS
0 200 400 600 800 1000 MILES
0 200 400 600 800 1000 KILOMETERS
Triangulation with precise topographic survey
Triangulation with approximate topography from plane-table sketches or traverses
Reliable traverses
Approximate traverses and compass sketches
Triangulation without other surveys
Unsurveyed areas
120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
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32
28
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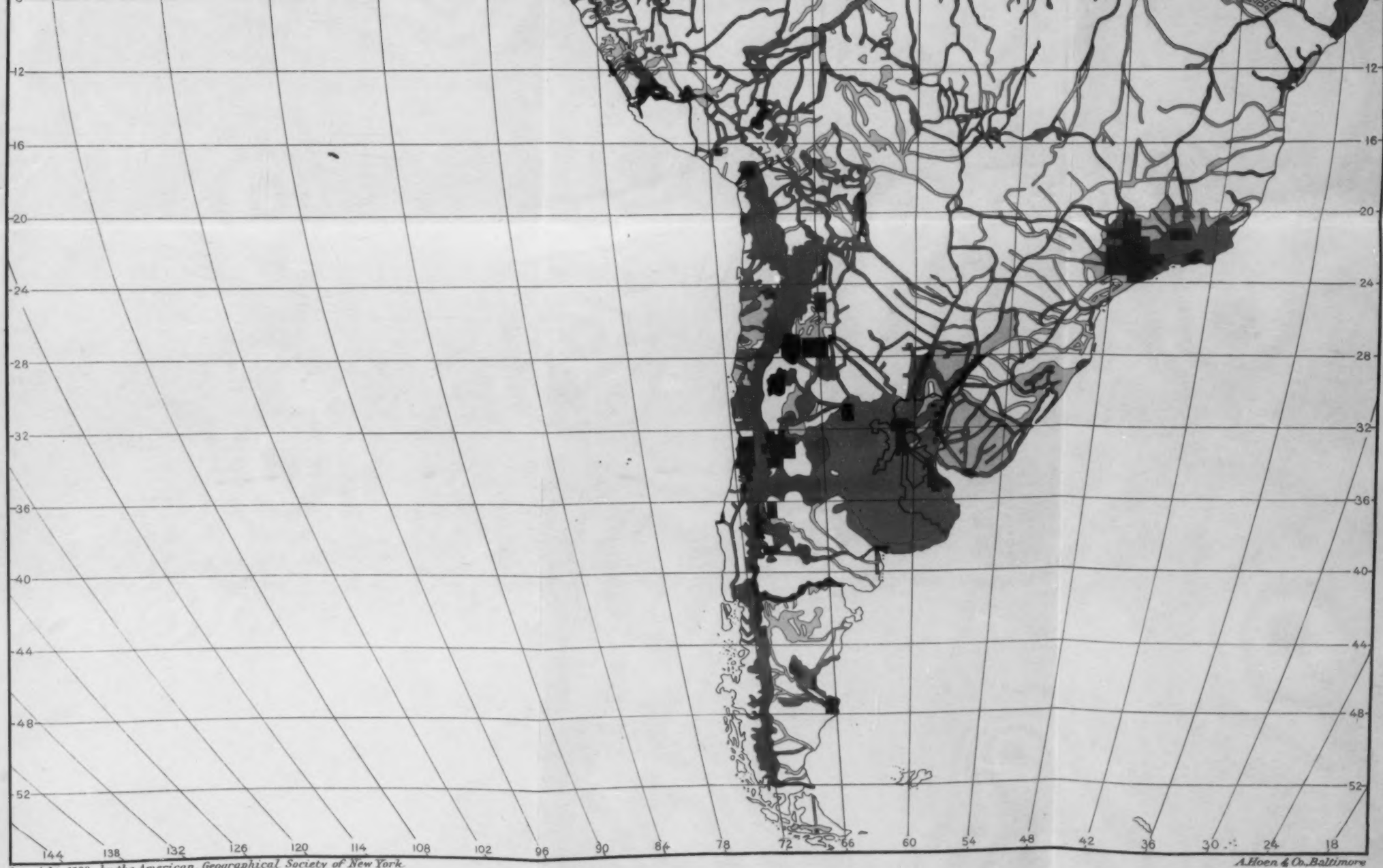

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GEOGRAPHY AT THE SOUTH AFRICAN MEETING OF THE BRITISH ASSOCIATION

Alan G. Ogilvie

University of Edinburgh

THE British Association for the Advancement of Science this year held its 97th annual meeting in South Africa, where the visiting members to the number of about 550 joined forces with the South African Association under the joint presidency of Sir Thomas Holland—of the British—and Mr. J. H. Hofmeyr—of the daughter Association. While some of the older members had attended the first South African meeting of the British Association in 1905, the great majority now had their first experience in the Union and indeed in the southern hemisphere.

Section E (Geography) was supported by a considerable number of British geographers and by the small but enthusiastic band of their South African colleagues. While the audiences at the Sectional meetings in Cape Town and Johannesburg were small in comparison with those of some other sections, the work accomplished was considerable and many of the papers read were of great interest. Moreover, the opportunity of a long if rapid journey through the territories of the Union and into Rhodesia was probably more valuable to the average geographer than to most other members of the Association. The writer was never before so impressed with the value of knowing—more or less—what to expect to see and hear in traveling through a new country. In short, the extreme specialization of science at the present time and the consequent narrowing—albeit also the deepening—of the furrow plowed by those engaged in many of its branches emphasizes the need for insuring that the next generation of scientists shall, in their earlier education, obtain something of the breadth of view of a Humboldt or a Darwin. For this purpose geography seems to be essentially adapted.

The following account is a brief report of the geographical matters presented at the meetings, together with a summary record of one field excursion.

Mapping in the Union

The Geography Section met on four successive days from July 23 in Cape Town and on two days, August 1 and 2, in Johannesburg, while a third day was devoted to a geographical excursion. The President, Brigadier E. M. Jack, Director General of the Ordnance Survey of Great Britain, devoted his address to "National Surveys."[1] Reference to it here may be confined to the statement that, starting with a useful comparative review of the principal national surveys of the world, it concluded with a discussion of the special survey situation in South Africa. Furthermore, in view of the great importance to the Union of adequate maps—a fact fully realized by geographers and others but apparently not yet by politicians—it is not surprising that four other important papers dealt with survey matters in Africa. Mr. G. T. McCaw spoke on the African Arc of Meridian, the measurement of which was begun from both ends but remains to be completed in its central part, where two gaps still exist, from 10° S. northward for about 9½° to Uganda, and again from Lake Albert to Wady Halfa, about 21°. Dr. Van der Sterr, Director of

[1] *Scottish Geogr. Mag.*, Vol. 45, 1929, pp. 257–276.

the Trigonometrical Survey in South Africa, gave an account of progress, and Mr. H. Whittingdale made a more general statement on Map Making in the Union. Mr. H. G. Fourcade dealt with a new method of aerial surveying, which is relatively simple and inexpensive but is nevertheless too complex to discuss here. It is greatly to be hoped that these contributions and the discussions which followed will arouse a general interest in the provision of accurate maps of the Union. The triangulation has been admirably carried out; but, save for the military map of the Orange Free State and part of the Transvaal, there are as yet no systematic topographic maps. South Africa in this respect has not passed the pioneer stage: there are innumerable isolated property plans made by private surveyors and controlled and registered by the Surveyor General; but until topographic maps are made there can be no adequate geographical research in South Africa.

Water Supply and Climate

The South African population is primarily dependent on agriculture and stock farming, which in turn are closely related to water supply. Great attention was therefore given to another group of papers. Mr. R. J. van Reenen, chairman of the Union Irrigation Commission, dealing with the Utilisation of Available Water Supplies in South Africa, pointed out that the country falls climatically into two unequal belts, the smaller southwestern area in which winter crops can be raised on a winter rainfall of 10 inches, and the much larger eastern region where, the rainfall being in summer, a minimum of about 20 inches is required. In South Africa only a small part (about 6½ per cent) of the rainfall reaches the rivers, and it is clear that the success or failure of agriculture in the future depends very largely upon the degree in which the remaining 93½ per cent is utilized by crops or fodder plants. There is much room for increased development of "dry farming" methods. For the above reason irrigation is limited, though there is still opportunity for its greater use mainly for fruit growing, which is the object to which most of the existing irrigation is devoted. Underground water is relatively little tapped, and in the future its greater employment is envisaged chiefly in the pastoral areas.

At present the menaces of the sheep farmer are drought and the jackal. Increased boreholes will help to meet the former, while the latter is most successfully being combated by enclosing the sheep runs by high fences. Within these, sheep need no longer be driven nightly to the kraal; and so labor is saved, and the sheep are kept in better condition as to flesh and wool. But subdivision of the enclosed farm is essential to the systematic use of the pasture, and water must be provided in each paddock, this being obtained chiefly by boreholes with wind pumps but also by underground collection in "dry" river beds.

Professor P. Serton made a most interesting review of the climatologist's definitions of a desert as applied to South Africa and with special reference to the western Karroo. This area in part at least receives less than five inches of rain per annum, which is probably less than in any part of the Kalahari. Moreover, such temperature data as exist would bear out the view of any climatologist that it is a true desert; and yet the geographer, making a synthesis of all the conditions affecting man, must come to another conclusion. The Karroo, with its well known succulent vegetation, its relatively small size, its strong relief, and its associated structure, presents a habitat for a race of pastoral farmers who, in spite of occasional loss from drought, refuse to accept it as a desert and indeed form a considerable population. Altogether, this paper was a model of the proper geographical approach to regional study.

Dr. Marion Newbigin also challenged the propriety of classifying natural regions on a purely climatic basis, her theme being the five world regions usually grouped on account of their "Mediterranean climate." Dr. Newbigin's well supported contention is that two of these, the southwestern Cape Province and southwestern and

southern Australia, do not exhibit on their landward margins the sharp contrast of climate and life that is a feature in the Mediterranean, in California, and in central Chile. In Australia especially the "Mediterranean" crops tend to be grown largely outside the climatic region. The speaker further challenged the view that lands of this climatic type are areas of great natural wealth capable of supporting dense populations of cultivators. Still another paper, by Miss M. R. Shackleton, dealt with man's exploitation of regions of specific climates, this time the various belts of Europe. Once more it was clear that geographers, with their attention rightly focused on human life, are questioning the validity of using for geographical purposes the climatic subdivisions of continents.

Settlement Illustrated by a Field Excursion

The visitors were treated to two most interesting presentations of the essentials of the human geography of the Union as a whole. Professor E. Walker dealt with the Effect of the Relief of South Africa on Settlement in an illuminating essay, to be published soon in the *Scottish Geographical Magazine*, which traced the course of European expansion from a few isolated patches of urban and agricultural activity along the coasts—an expansion directed in masterful fashion by the relief of the interior plateaus with their fringing ranges and passes. And the relief in turn determines the form of the 25-inch isohyet, along which were fought out the so-called Kaffir wars of the first half of the nineteenth century and the Free State-Basuto wars of the early second half—all of them struggles between Black and White for good cattle land. Though the Union underwent a partial industrial revolution in the seventies, the frontier atmosphere is still widespread owing to the course of this geographically determined history.

Professor Walker's paper formed an admirable introduction to the paper at Johannesburg by Professor J. H. Wellington on Physical Influences in the Human Geography of South Africa, which was concerned to a greater extent with present conditions. It presented an excellent synthesis and incidentally showed how completely the geographer after but few years of residence in this fascinating country may become imbued with the spirit of its life and environment. Professor Wellington followed up his broad account by leading the Geography Section on a hundred-mile journey through the interesting region north of Johannesburg.

The route started westward along the Witwatersrand escarpment, from which impressive views are obtained. This north-facing scarp of quartzite today forms the Vaal-Limpopo divide; and from it, standing on the high northern rim of the grass veld, one looks over a lower rolling country of granite in the east with overlying dolomite in the west, the latter from its porous and water-bearing characters acting as the feeder of the several headstreams of the Crocodile River that have water in the dry season. In consequence, there were many evidences of rich irrigated and permanent agriculture in this area which the party traversed in reaching the next feature of the district. This is the remarkable series of abrupt scarped ridges of quartzite, of which the Magaliesberg is the highest, most northerly, and most continuous. The ridges are pierced by numerous *poorts*, mostly water gaps but some wind gaps, bearing witness to river capture since the whole Crocodile system superimposed by the denudation of the Karroo System of rocks that must formerly have overlain the whole region. At the main *poort* in the Magaliesberg the Crocodile has been dammed by a barrage, and the resulting Hartebeest reservoir was seen as the cause of fertility in a long zone of canals and orchards penetrating northward into the Central Bushveld of the Transvaal. The economic success of this irrigated area, however, seems doubtful, perhaps owing to lack of skill and inefficient labor. In descending from the High Veld to this point the transition from grass to bush was seen to advantage in the Protea bushes of the slopes and the varied but mostly thorny and small trees of the stream banks.

On the return journey eastward along the broad valley (Die Moot) between the scarps to Pretoria, a city founded at a *poort* on the Rapies River, and thence southward again to Johannesburg the route lay through grass veld, and some of the party were fortunate in the sight of a large herd of springbok, now rare here, galloping in single file—a glimpse in fact of the High Veld as it was. In short, Professor Wellington could not have arranged a more profitable day.

Other Contributions

Contributions relating to pastoral topics in Australia and New Zealand were made by Professor O. H. T. Rishbeth and Mr. R. O. Buchanan respectively. The former, after outlining the points of likeness and difference, geographical and economic, in the pastoral regions of the three southern continents, examined the present Australian problems in regard to the dairying, sheep, and beef cattle industries. Mr. Buchanan's paper on the Dairying Industry in New Zealand portrayed the ideal climatic conditions in the North Island for milk production—ample rainfall with winter maximum but no summer drought; most equable temperature; fine soils, basaltic or river silts; good pine wood for box making, hydro-electric energy. Hence there is a great cattle density, especially below 650 feet, and an all-year milk production, with local specialization due to geographical variety.

The field of historical geography was represented first by Mr. R. A. Pelham's paper on Trade between England and West Africa during the Early Years of the Eighteenth Century. This included, of course, the transatlantic trade via the West Indies in which the most valuable commodity was slaves. Mr. Pelham has searched the journals and account books of the Royal African Company and other documents, including ships' logs, and his results threw much light upon climatic and other conditions of the voyages as affecting slave mortality. Secondly, Professor H. J. Fleure lectured on European Cities, basing his classification upon the character of origin as revealed in the plan of the nucleus and tracing the spread of the city with its attendant religious and commercial organization from its original home on the Eastern Mediterranean westward and northward as the later Roman quadrate city through Gaul to the Rhine. In these last, many later became bishop's cities, with the cathedral dominant. North of the Alps and the Balkans the village remained the typical form of social expression until early medieval times, but the formation of cities then was of similar origin. On the other hand the commercial city grew up in Flanders and North Germany with its central square, guildhalls, civic church, and its harbor connections.

Turning to modern conditions, attention should be called to the annual Report of the Committee on Human Geography of Tropical Africa, made by Mr. A. G. Ogilvie. This committee, set up in 1927, has now enlisted the services of several correspondents in Africa, who will each study on the spot the detailed relationship of the native to the land he inhabits. The committee during the coming year will issue a pamphlet throughout the British Territories which, it is hoped, will induce other helpers to coöperate there. In England work has been carried on towards the preparation of maps of population distribution, those of the East African Territories and of Nigeria being complete.

Professor P. M. Roxby's treatment of the Expansion of China, the result of long study and mature thought on a great question, will be published soon in the *Scottish Geographical Magazine* and must here be passed over. Professor C. B. Fawcett, on the Location of the British Empire in Relation to the Old World, drew attention, with the help of interesting maps, to the position of the British possessions as arranged (1) on an inner ring round the perimeter of the Old World (counting the Sahara as beyond this), consisting of British India and colonies, etc., not self-governing and (2) an outer ring composed mainly of the great self-governing domin-

ions all lying in the New World as now defined. It is useful to bear these space relations in mind when looking forward to the time when the British Isles no longer will be the most populous part of the Commonwealth. Dr. Vaughan Cornish alone spoke on Great Britain when he gave one of his now well known appreciations of scenery—this time of England and Wales. A characteristic of this as of his previous studies on the harmonious grouping of landscape features was the essential harmony of the language used and the beautiful photographs exhibited.

In the regrettable absence of Mr. Frank Debenham his review of the Problems of the South African Sector of Antarctica was read by Miss W. M. Drake. The purpose of this lecture was to bring home to South Africans their vital interest in the exploration of the Polar Continent between 15° W. and 80° E., especially in the practical bearings of research upon meteorology and oceanography, including ice movement and marine fauna. It was a fitting prelude to the visit of Sir Douglas Mawson in the *Discovery* on his way to investigate these problems.

Finally, half a day was devoted to a series of contributions and a discussion, along with the Education Section on the Teaching of Geography, with special reference to South African schools and colleges. Professor F. J. Plummer presented a very full report, and from this and other evidence it was made abundantly clear that geography has as yet no wide appeal in the Union as a subject of great educational value. More specifically, the progress of the subject is hindered by examination regulations for secondary schools, into which we cannot go here, while the demand for a good knowledge of both English and Afrikaans greatly reduces the time which can be spent on studying geography.

Allied Interests in Other Sections

In conclusion, it may be useful to give the titles of papers in various sections of the Association which have a distinct geographical bearing, for most of these will doubtless subsequently be published. Section A (Physics), Sir Gilbert Walker: Meteorology in Application. C (Geology), Professor Richards: The Great Barrier Reef Expedition. C, D, and K, Joint Discussion on Gondwanaland. D (Zoölogy), Dr. Annie Porter: Some Remarks on the Hookworm Problem in South Africa; G. S. Carter: Bionomics of Swamps and Marshes, Especially Those of the Tropics. F (Economics), J. W. F. Grosskopf: The Agricultural Land of South Africa and Its Users; J. E. Holloway: The Demographic Position in the Union of South Africa. F, H, Joint Discussion on Economic Competition between Advanced and Backward Peoples. G (Engineering), S. H. Frankel: Road and Rail Transport in South Africa; Philip Johnson: Transport Costs in Roadless Countries and the Possibilities of Mechanization. H (Anthropology), Henry Balfour (President): South Africa's Contribution to Prehistoric Archaeology; H. J. Fleure: Racial Drifts in Africa and Europe; L. S. B. Leakey: An Outline of the Stone Age in East Africa; E. J. Wayland: The Present Position of Stone Age Research in Uganda; L. Frobenius: Investigations in Southern Rhodesia; Miss G. Caton-Thompson: Excavations of Great Zimbabwe; P. Wagner: A Map of the Distribution of Pre-European Mining in the Transvaal and Southern Rhodesia. K (Botany), R. S. Adamson: The Vegetation of the Cape Peninsula; A. S. Hitchcock: Grasses in Relation to Man; (Discussion) Origin and Evolution of South African Flora; C. E. Moss: Vegetation of South Africa, with Special Reference to the Witwatersrand District; I. B. Pole-Evans: The Botanical Survey of South Africa; J. V. Phillips: Some Important Vegetation Communities in the Central Province of Tanganyika Territory; T. A. McElhanny and R. D. Craig: The Canadian Forest Industries; J. Burtt Davy: Distribution of the Forest Flora of Nyasaland; P. Topham: The Influence of Man on Forest Environment in Northern Nyasaland. L (Education), E. G. Malherbe: Education and the Poor White.

AMERICAN GEOGRAPHICAL SOCIETY

The November Meeting. The first regular meeting of the American Geographical Society for the season 1929–1930 was held on November 26, 1929, at the Engineering Societies Building, 29 West 39th Street, President John H. Finley in the chair. Dr. Harlow Shapley, Director of the Harvard Astronomical Observatory, addressed the Society on "The Third Dimension of Geography." Using the earth as a sample of the sidereal universe, he examined various terrestrial problems from an objective viewpoint, leading his audience in some novel explorations of the planet.

At the meeting there were presented with the approval of the Council the names of 631 candidates who were duly elected as Fellows of the Society.

Conference on Air-Navigation Maps. On October 26, 1929, the Society held at its building a conference on air-navigation maps. The following were present on invitation: Colonel C. H. Birdseye, Aerocartographic Corporation of America (formerly Chief Topographic Engineer, U. S. Geological Survey); S. W. Boggs, Geographer, Department of State; Lieutenant Harold Brand, Army Air Corps, War Department; W. L. Hamilton, Curtiss Flying Service, also representing United Aircraft and Transport Corporation and Aeronautical Chamber of Commerce; B. R. Holcombe, Pan American Airways, Inc.; H. S. Huntington, New York, Rio & Buenos Aires Line, Inc.; T. P. Lampe, Hydrographic Office, Navy Department; E. H. Pagenhart, Division of Charts, U. S. Coast and Geodetic Survey; R. L. Ross, Airway Charting Section, U. S. Coast and Geodetic Survey; Lieutenant J. P. W. Vest, Hydrographic Office, Navy Department. Isaiah Bowman, W. L. G. Joerg, O. M. Miller, and R. R. Platt represented the American Geographical Society.

The Conference was called to inquire into the need for improvement in present air-navigation maps or the development of completely new types of maps to meet the requirements of aviators and to make plans for experimental work looking to the fulfillment of this need. It was hoped that, by bringing together experts from representative corporations engaged in commercial aviation and from bureaus of the Federal government concerned with the development of air navigation as well as those engaged in the production of aviation maps, the type or types of maps needed and the technical problems involved in their construction might be freely discussed and the way opened for practical experimentation. It seemed advisable that, if a type or types of maps were to be produced that would satisfy the needs of all phases of air navigation, the experimental work should be conducted by a representative group working together under conditions unhampered by the limitations natural to the conditions of procedure both in government bureaus and in commercial companies. To this end the Society offered its services, it being understood that the Society was interested in the work only as a problem of practical research the results of which would be equally available to all concerned in the production and use of air-navigation maps.

The conference engaged in a general discussion of the whole problem, and many of the aviator's requirements that have as yet not been satisfied by air-navigation maps were brought out. It was the general consensus of opinion that no one type of map would satisfy the requirements but that different types of map would have to be developed such as general maps for planning flight routes, more detailed maps for flying from point to point on such routes, and large-scale maps of landing fields. It was generally agreed that many existing conventions of map construction would have to be discarded (choice of detail, symbols, etc.) and new ones established.

Before the conference ended resolutions were adopted as follows: (1) That this group be formed into a permanent committee to take up the study of airway maps; (2) that Mr. Joerg (of the American Geographical Society) be made chairman of this committee, that he be empowered to appoint an executive committee, and that the executive committee should be given the power to add to or reduce the present membership of the permanent committee.

It was agreed that experimental work should be started as soon as possible on air-navigation maps of two areas chosen by the committee, one in the United States and one in South America. Plans were discussed for raising a small fund for initiating the experiment.

Distribution of Title Page, Contents, and Index of Volume 19 of the Geographical Review. The index for Volume 19 of the *Geographical Review* (1929), together with title page and table of contents, is ready for distribution. Copies are sent to all institutions exchanging publications with the Society and to individuals who request that their names be put on a list for this purpose.

A New Map of the Antarctic Distributed to Educational Institutions. In the month of November the Society distributed to 16,000 universities, colleges, normal schools, high schools, grammar schools, and private schools in the United States copies of a new map of the Antarctic in three colors. The map measures 43 x 53 inches over all and is intended to be used as a wall map. It consists of three parts, (1) a main map on the scale of 1:12,500,000, showing the Antarctic in relation to the southern continents; (2) an inset on the scale of 1:2,500,000, showing the Antarctic Archipelago, the route of Captain Sir Hubert Wilkins from Deception Island to Hearst Land and return, and indicating the newly discovered features and the names applied to them; and (3) a series of ten photographs taken by Sir Hubert Wilkins arranged in the order of the flight from north to south as seen from the air.

Accompanying the map is an "Explanatory Booklet" embracing: (1) a description of the Map of the Antarctic in some detail; (2) an account of Wilkins' Antarctic Expedition of 1928–1929 as originally published in the *Geographical Review* for July, 1929; and (3) an explanation of air navigation in the Antarctic. The booklet is illustrated with 38 figures, including 37 photographs of Antarctic subjects and a reduced photograph of the American Geographical Society's Navigational Chart of the Antarctic from the base supplied to Captain Wilkins, Commander Byrd, and Sir Douglas Mawson, all three of whom are now heading major expeditions in different sectors of Antarctica.

The distribution is intended to facilitate reference to the work and discoveries of the three major expeditions now in the field and to help in the realization of the map as a living, changing thing.

Two Polar Maps and Exploration in the Antarctic. The Society will have ready for distribution in January two special maps, one of the Arctic and the other of the Antarctic. The map of the Arctic, 18 by 23 inches in size, is a physical map embracing a circular main map of the area from the pole to latitude 58° N. on a scale of 1:20,000,000 and insets, on larger scales, of the northern outlet of Baffin Bay, of southwestern, northernmost, and northeastern Greenland, Jan Mayen, Bear Island, the Ice Fiord region of Spitsbergen, Spitsbergen (Svalbard), Franz Josef Land, Novaya Zemlya, and Bering Strait. Relief of the land is shown by layer coloring in five tints combined with hachures, and the tundra is distinguished by shading; bathymetry is shown by layer coloring in five tints. Inland ice, glaciers, drift ice and its farthest limits, and ocean currents are indicated; also, according to Otto Nordenskjöld (*Amer. Geogr. Soc. Special Publ. No. 8*, pp. 72–86), the boundary of the Arctic as a natural region. The leading routes of exploration by ship and sledge

and by air are shown within the land-encircled Arctic Basin, with the farthest points attained: remaining unknown areas are in white.

The map of the Antarctic, 23 by 25 inches in size, is primarily a bathymetric map of circum-Antarctic waters. As it includes the southern parts of South America, Africa, and Australia, the map embraces practically all of the Atlantic, Indian, and Pacific oceans within the Southern Tropic. Bathymetry is shown by a large number of soundings and by means of layer coloring in nine tints, buff for the continental shelf and eight shades of blue for the oceanic depths. As the map is on the same scale, viz. 1:20,000,000, and as the major geographical features of the land areas are shown, although not their relief, it is directly comparable with the physical map of the Arctic. It is likewise on the same scale as the revised bathymetric map of the Arctic Basin by Dr. Fridtjof Nansen published in the Society's *Special Publication No. 7* ("Problems of Polar Research"), and its method of representing the depths of the ocean is the same. Nansen's map and the bathymetric map of the Antarctic therefore constitute companion tools in the study of polar oceanography.

The two maps will be accompanied by a pamphlet describing them and setting forth their bearing on the present period of polar exploration. The maps and pamphlet will be distributed in a case corresponding in height to the *Special Publications* series of the Society and suitable for placing on a library shelf.

The situation of the three major expeditions at the beginning of December may be briefly stated here. After the preliminary exploratory work of last season (see "Antarctic Flights of 1928–1929," *Geogr. Rev.*, Vol. 19, 1929, pp. 307–310) Commander Byrd's expedition took the field again on October 16 when a depot-laying party set out to prepare the way for the geological party. On November 4 the geological party under Dr. Laurence Gould started their 440-mile sledge journey due south to the Queen Maud Mountains, where they will be engaged for the remainder of the season in an area of critical importance. On November 19 Byrd flew to this range to establish a base for the polar flight at the foot of Mt. Fridtjof Nansen, the 15,000-foot peak west of Axel Heiberg Glacier. A new range in Carmen Land was seen and named (Charles Bob Range), but Amundsen's "appearance of land" to the east between latitudes 81° and 82° was not confirmed; instead the width of the Ross Shelf Ice (Ross Barrier) is extended here by 100 miles. The geological party reported on December 7 that it had succeeded in crossing the frightfully crevassed ice at the foot of Mt. Fridtjof Nansen and had climbed "6500 feet up" the northern slope with most promising geological prospects at hand.

Reports from the geological party then 300 miles out and upper air observations gave a favorable weather forecast on November 28, and at 4 p. m. (local time) Commander Byrd began the great flight to the pole, 800 miles away, one of the major objectives of his expedition. With him were Bernt Balchen and Harold June, pilots, and Captain Ashley McKinley, operating the surveying camera. The mountain rim of the plateau presented the chief difficulty to the fliers. Liv Glacier, west of Axel Heiberg Glacier, Amundsen's route, was selected as the most promising approach. Violent up-and-down air gusts made the passage to the plateau very rough, but by climbing to an altitude of 11,500 to 12,000 feet the plateau was attained. Seemingly new mountains were seen in addition to those described by Amundsen: then finally nothing but the "limitless plateau," which seemed to be sloping gently downwards to the pole. When it was judged that the pole had been reached, a circuit was made and the plane headed north. The return followed a meridional course "with such precision that they struck Axel Heiberg Glacier in the middle." Coming out of the mountains an eastward detour was made until the need for refueling compelled return to the depot, whence the homeward flight was uneventful. Little America was reached at 10.10 a. m. November 29. The surveying camera was in operation throughout the trip.

On December 5 Commander Byrd flew into the unknown area east of King Edward

VII Land, 350 miles out in a northeasterly direction from Little America. He followed the coast and beyond the 150th meridian, the eastern limit of Ross Dependency, discovered a mountain range trending north and south and separated from the Alexandra Mountains by a deep valley, apparently an inlet of the sea. At the 75th parallel he turned and skirted the new range until satisfied of its penetration far into Marie Byrd Land. From the turning point the coast here running northeast could be seen in the distance to trend eastward after dipping to the south. This excursion into "the greatest blank space on the map" (Sir Douglas Mawson in "Problems of Polar Research," p. 256) is of profound importance. The coast here is peculiarly unapproachable, pack ice extending far northward. In 1928–1929, for instance, the *Norvegia* skirted heavy pack here just without the Antarctic Circle. Captain McKinley surveyed the route with the aerial camera and he has photographed in similar fashion the entire Bay of Whales with its inlets and crevasses.

Captain Sir Hubert Wilkins arrived at Deception Island on November 13 to resume work in the Graham Land sector. He found planes and supplies stored on the island in good condition; but the weather, alternately freezing and thawing, was of a most unfavorable character. A week later the R. S. S. *William Scoresby* put into Deception harbor. This vessel, placed at Captain Wilkins' disposal by the British Colonial Office, will pursue routine work but within call to carry the expedition to a more southerly base if this is deemed necessary. The *William Scoresby* is the second vessel of the Discovery Committee conducting oceanographic and whaling investigations in the South Atlantic (see *Nature*, September 28, 1929, pp. 483–486). The *Discovery*, the first ship, has been chartered by the Commonwealth Government for Sir Douglas Mawson. To replace it a new vessel, the *Discovery II*, has been built.

Sir Douglas Mawson is also returning to the scene of former accomplishments. He will continue the notable work carried out by the Australasian Antarctic Expedition of 1911–1914 in that sector of the Antarctic south of the Indian Ocean. Captain J. K. Davis, master of the *Aurora* on the earlier expedition, again is Mawson's second in command and master of the *Discovery*.

Departure was made from Cape Town on October 19. The Crozets were reached November 8, a stop being made at Possession Island, and Kerguelen on November 13. Here the *Discovery* coaled before making for Heard Island and the Antarctic threshold. Heard Island lies some 1000 miles northwest of Gaussberg, Drygalski's base in 1901–1903, and the western limit of the *Aurora's* explorations. Sir Douglas plans to sail in this direction, making temporary landings on the coast if the ice permits; if not, cruising over as wide a range east and west as possible. In any event the ship is the permanent base, and the oceanographical work of prime importance. The expedition also carries a small scouting airplane.

Meanwhile Norwegian whaling interests are prosecuting scientific as well as commercial researches in Antarctic and sub-Antarctic waters. Consul Lars Christensen's *Norvegia* is following her successful cruises of 1927–1928 and 1928–1929 (shown on Plate I of Bjarne Aagaard's "Fangs og Forskning i Sydishavet") by a projected circumpolar voyage. According to information received from Consul Bjarne Aagaard, Riiser-Larsen, who is attached to the expedition, has already photographed Bouvet Island from the air and hopes to carry out a similar survey of Peter I Island. Captain Gunnar Isachsen, author of "Norwegian Whaling in the Antarctic" in the July, 1929, number of the *Geographical Review*, is also in the Antarctic on Consul Christensen's floating factory *Thorshammer*.

GEOGRAPHICAL RECORD

NORTH AMERICA

Hudson Bay Today. The preamble to the charter of the Hudson's Bay Company granted in 1670 states that the founders "have at their own great cost and charges undertaken an expedition for Hudson Bay in the North West part of America for the discovery of a new passage into the south sea, and for the finding of some trade for furs, minerals and other considerable commodities, and by such there undertaking have already made such discoveries as do encourage them to proceed further in Pursuance of their said design, by means whereof there may probably arise very great advantage to us and Our Kingdom." Since that time with few interruptions the Company's ships have made the annual voyage to the Bay, successfully pursuing trade and exploration. Mr. George Binney, leader of the Oxford University expeditions of 1923 and 1924, who has taken part in three recent voyages, describes conditions as they are in the bay today (George Binney: Hudson Bay in 1928, *Geogr. Journ.*, Vol. 74, 1929, pp. 1–27). His account is particularly interesting from the fact that it comes on the eve of the new era expected in this part of Canada with the opening of the Hudson Bay Railway.

Navigation is of first interest, and here the "stumbling block" is Hudson Strait. "Les anglais regardant les difficultés de cette navigation comme le meilleur rempart de leurs établissements empechoint la publicité des cartes," wrote Lapérouse in 1782 (C. Duplomb: Lapérouse à la Baie de Hudson en 1782: Une lettre inédite, *La Géographie*, Vol. 51, 1929, pp. 145–148). No continuous survey of the coasts of the strait has yet been made, nor are we adequately informed of ice conditions and their variations from year to year. Are the variations cyclic and can they be forecast? Mecking in his paper "Die Hudsonbai-Bahn, ihr Hafen und ihr Seeweg" (*Petermanns Mitt.*, Vol. 75, 1929, pp. 249–257), hints at a correlation between sunspot maxima and unfavorable ice years such as he has found for the Labrador coast and Hudson Bay, but available data are still too scant for analysis. This defect, however, is now on the way to being remedied, for wireless stations are being set up in the strait. In 1928 stations at Port Burwell, Cape Hopes Advance, and Nottingham Island were making "accurate records of ice and weather conditions" (N. B. McLean: Report of the Hudson Strait Expedition, 1927–28, Ottawa, 1929).

The strait is deep and wide, but good harbors are lacking. Mr. Binney commends Hebron on the northeastern coast of Labrador, and Dorset in the southwestern corner of Baffin Island; but Burwell at the eastern extremity of the mainland of the strait is poor and notorious for its fog, while Wolstenholme at the western extremity has an equally bad name for winds. Within the bay the east coast is likewise deficient, the only known natural harbor for ocean-going vessels being Port Harrison, though harbors may exist in the Belcher Islands and Ottawa Islands. The waters of the south coast are extremely shallow. If the Temiscaming and Northern Ontario Railway now within 80 miles of James Bay, or its competitor the Algoma Central and Hudson Bay Railway, reaches the shores of the Bay there will be found difficulties in securing deep water approaches to Moose Factory (compare E. M. Kindle: The James Bay Coastal Plain: Notes on a Journey, *Geogr. Rev.*, Vol. 15, 1925, pp. 226–236). In Quebec the line now building from Chicoutimi via Lake St. John to the gold-silver-copper field of Chibougamau may ultimately be carried down the Nottaway River to Rupert's House, the first established station of the Hudson's Bay Company (H. S. Patton: Canada's Advance to Hudson Bay, *Econ. Geogr.*, Vol. 5, 1929, pp. 215–235). But these railways would seem to be designed to exploit

the mineral and timber wealth of their regions, rather than as export routes via James Bay.

On the west coast Churchill on the tongue of land between the mouths of the Hayes and Nelson rivers now takes the place of preëminence as the terminus of the main highway into the interior, held in the prerailway days by York Factory. It was by this latter route that the first settlers of the Canadian Middle West arrived in the early years of the nineteenth century (compare F. J. Alcock: Past and Present Trade Routes to the Canadian Northwest, *Geogr. Rev.*, Vol. 10, 1920, pp. 57–83).

Completion of a railroad to the bay and introduction of airplane and tractor, while bidding fair to solve some problems, heighten others, notably that of the native inhabitants, Indian and Eskimo. "*Bon canot!* How much him cost?" asked an old Indian after his first ride in an airplane (J. A. Wilson: Gentlemen Adventurers of the Air, *Natl. Geogr. Mag.*, Vol. 56, 1929, pp. 597–642). He was not slow to appreciate the ease and speed of this journey of half an hour against the customary six days on the ground. The native has always been ready to adopt the tools of civilization; but what have they cost him? Rifle and motor boat and the like have all too frequently turned his primitive economy to a truly robber economy and with disastrous results. This is appreciated by the great fur companies. Mr. Binney observes that the airplane has not been encouraged in places where its use might seem obviously advantageous because it would cost the Indian his spring and summer employment—carrying furs out of the interior and bringing in supplies. Steady employment for the native is the crux of the matter.

In the search for a solution there naturally arises the question of a more complete utilization of the resources of the country, notably of the grazing grounds. Mr. Stefansson is the well known advocate of such a measure, but it is not new. His experiments with the wool of the musk ox (ovibos) were anticipated two hundred years ago by Nicolas Jérémie. Jérémie, in the employ of the Compagnie du Nord at the turn of the seventeenth century, sent samples of this "beautiful wool" to France from which were made stockings "finer than those of silk" (Twenty Years of York Factory, 1694–1714, Ottawa, 1926. Translation from the original French of 1720 by R. Douglas and J. N. Wallace).

No attempt has yet been made to domesticate the musk ox, but on the other hand a long-standing major project, the introduction of reindeer, seems to be in the way of realization; at least it is to be given an adequate trial. The November, 1929, number of *Natural Resources, Canada* reports that a herd of 3000 animals purchased by the Department of the Interior from the Alaskan herds is now on its way east. The step is being undertaken only after an exhaustive study by Messrs. A. E. and R. T. Porsild. It involved investigation of the industry in Alaska and examination of prospective Canadian grazing grounds, for "the chief grazing problem of the Arctic ranchers is not directly climatic but rather botanical" (The Resources of the Arctic and the Problem of Their Utilization in "Problems of Polar Research," *Amer. Geogr. Soc., Special Publ. No. 7*, 1928, pp. 209–233). The herd will travel by slow stages via the headwaters of the Noatak River and the Colville Basin where it will rest for the fawning season. It is expected to cross the Mackenzie delta before the ice breaks up in the succeeding year (1931). The reindeer will be placed on a reserve of 15,000 square miles, and as they increase smaller herds will be established in other selected areas of the north.

Migrations of the Paper Industry in North America. The newsprint paper industry in general has shifted from United States territory to Canada, until today Canada is the world's largest manufacturer of this kind of paper. The situation is analyzed by Andreas Predöhl in an illuminating paper "Die Wanderungen der amerikanisch-kanadischen Papierindustrie" (*Weltwirtschaftliches Archiv*, Vol. 29,

1929, pp. 285–330). While the industries in our own country show something less than a ten per cent increase in output between 1913 and 1927, the Canadian production increased nearly sixfold and is now nearly fifty per cent greater than ours. The Canadian industry focuses upon the St. Lawrence Valley and gives every indication of remaining there indefinitely. A marked expansion has taken place in Newfoundland.

In contrast with newsprint production, book and writing paper output is nearly twice as great in the United States as in Canada. Furthermore, the output of wrapping paper and cardboard in Canada is negligible as compared with that in the United States, being only about one-sixteenth as great.

The newsprint paper industry has migrated northward while the other branches of the industry have remained nearly stationary except for a slight westward expansion and a somewhat greater increase in output in middle-western mills than in the eastern. Dr. Predöhl accounts for these differences upon the basis of differences in the nature of raw materials used, their costs including cost of transportation, comparative value of the finished products, and the integrating of the industries. An important element influencing the location of the newsprint paper industry more than other paper manufactures is low power costs. Those localities that have water power available near the raw materials or that are located on transportation routes which permit of low cost deliveries of raw materials, including not only wood but chemicals such as sulphur, clay, soda, and others, have distinct advantages in the development of this industry.

While the Canadian paper industry probably will hold its own in the future, even though new methods are worked out in the utilization of a variety of woods not now employed, yet our own South is in a position to develop an important industry in the manufacture of kraft paper. Should processes be derived whereby this brown paper can be converted into a white product, that is a newsprint product, then the Canadian development would more than likely be retarded. Southern woods are cheap, labor is likewise cheap and abundant, while the distance to the consuming markets of the Great Lakes region and Atlantic seaboard are not prohibitive for economical deliveries. However, the southern development is more potential than real and is not likely to be realized in the near future.

The difference in the migration of the newsprint paper industry from that in other branches of the paper industry cannot be explained entirely upon an economic basis. It involves too a political situation—Canadian newsprint paper has been on the free list of the United States customs since 1911, and all other foreign newsprint paper since 1913; and in so far as this has been the case the development of this phase of the paper industries has not been handicapped. However, tariffs have been levied upon book paper, wrapping paper, and still other kinds; and this in turn has checked Canadian exports to the United States and hence retarded the growth of the industry in Canada. Thus the American manufacturers of the latter kinds of paper have enjoyed a competitive advantage which has helped them in holding their own, while the newsprint paper producers have had to give way before the Canadian development. As a corollary to the duty placed upon finished products, we have retained wood pulp upon the free list.

Dr. Predöhl concludes that, in spite of political influences and numerous economic factors, the westward movement of the paper industry as a whole has after all been more truly an expansion paralleling the western settlement of the country than a migration at the expense of an eastern decline, for the industry in the east has shown a healthy growth even while that in the west has increased. On the other hand the northward movement into Canada has been influenced largely by the recession of the forest, whose front has continued to lie relatively close to the eastern consuming markets.

EUGENE VAN CLEEF

Recent Population Changes in New York State. The state census of 1925 supplemented by the federal agricultural census of the same date reveals some extraordinarily interesting trends towards change in the population distribution of New York State. From 1855, when the rural population comprised 60 per cent of the total, to 1920 when the figure was only 17.3, decline has been steady; and in the latter decades (from 1880) it has been absolute as well as relative. Between 1920 and 1925 this movement was reversed, the rural percentage rising to 17.9. All counties but one (a small decrease was registered in Allegany County) showed increase, whereas in the previous decade 32 counties showed decrease. The phenomenon is analyzed by Bruce L. Melvin in "Rural Population of New York, 1855 to 1925" (*Cornell Univ. Agric. Exper. Sta. Memoir 116*, 1928). This study, primarily statistical, is equipped with a comprehensive set of cartograms and tables.

As a preliminary step rural population is defined. The census classification of rural population as that living outside incorporated places of 2500 and over is too inclusive and by that misleading. For instance, says Mr. Melvin, "In Suffolk County, rural population is a combination of suburban people who live within both incorporated and unincorporated towns and villages, farmers, and a great bulk of people who live in no locality sufficiently compact to have a name but who are not farmers. In Allegany County, rural population is predominantly farming. The distributor of cream separators could not depend on the information furnished by the census to determine where to advertise his wares."

Mr. Melvin subdivides rural population into incorporated villages, unincorporated villages, farm population, and non-farming-non-village population. He further introduces a useful classification of the counties of the state into urban, with more than half the population in cities of 10,000 and over; farming, with less than half the population in cities and with the largest farm population; suburban, with most people in small cities, towns, and villages; mountain, with a sparse village and farm population.

We find that in the lustrum 1920–1925 rural population in the groups of incorporated villages and unincorporated villages and non-farming-non-villages increased, the two latter together showing the largest gain of all population groups in the state, 41.1 per cent. The data indicate that the movement is particularly related to the suburbanization process. Farm population decreased by 4.3 per cent as a whole, but grew 5 per cent in the suburban counties, while the total rural population in these counties grew 33.8 per cent. Proximity of cities seems to have a favorable effect on the density of rural population. Professor A. P. Brigham pointed out in his paper on "The Population of New York State" (*Geogr. Rev.*, Vol. 2, 1916, pp. 206–217) that in the period 1900–1910 the rural population generally held its own in regions within 100 miles of New York City. The first response of farm population to suburbanization is the stimulation of vegetable and truck growing; later, as the city pushes out its bounds, land may be forced to suburban uses. In the suburban counties the growth from 1920 to 1925 was 27.5 per cent against 6.8 per cent in the previous decade. Sullivan County rose from the rank of a "mountain" county in 1920 to a suburban county in 1925 by reason of its nearness to New York City and to good roads. Here undoubtedly is a major factor in population distribution changes.

Some specific instances of these changes are given by Professor Brigham in "Glacial Geology and Geographic Conditions of the Lower Mohawk Valley" (*N. Y. State Museum Bull. No. 280*, Albany, 1929). The larger part of his memoir is devoted to an interpretation of modifications in the great eastern "gateway" due to Pleistocene glaciation, but the account is rounded out by a short survey of human transformation of the landscape. Among other things he notes the revival of road transportation in the area. "Except in the Adirondacks there is no point in our four quadrangles [Amsterdam, Fonda, Gloversville, Broadalbin] which is not easily accessible to a good road." The Cherry Valley turnpike, the shortest route between Albany and Syracuse and the great western highway of a century ago, had long since fallen to the rank of a

country road. "The writer saw one section of that road in 1907 . . . In three hours, seeing short grass, a few oats, two hop fields and not much else, he drove 12 miles on the ancient turnpike, met one team and was overtaken by no one. On a recent visit he looked out from a great hill upon the road, which was full of speeding motor cars." Many flourishing settlements of the pre-railroad era, forgotten for the nonce, have come to life again. "Now long-distance transportation, a network of local good roads, the rural free delivery, the telephone, the radio and the motor car have brought the world to the rural citizen's door."

The Model Weather-Reporting Service over the California Airway. The story of the weather-reporting service over the California airway between Los Angeles and San Francisco—a "model" service in the full sense of the word—is told, in a most interesting manner, in Major Edward H. Bowie's pamphlet, "Weather and the Airplane," published by the Daniel Guggenheim Fund for the Promotion of Aeronautics (New York, 1929). This service was inaugurated in June, 1928, being sponsored by the Fund for one year, with the coöperation of the Pacific Telephone and Telegraph Company, the Air Services of the Army and Navy, the Department of Commerce, and the Weather Bureau. As is stated in the preface, "the service was established to demonstrate the necessity and value of a permanent system of this kind which would eventually include all the nation's airways." From its start, this service has been an unqualified success and has convincingly demonstrated what meteorology can contribute to the safety and the efficiency of the aviator. Major Edward H. Bowie, of the San Francisco station of the Weather Bureau, is in charge.

A network of observing stations and of subobservation control points, dotted along and near the air route, supplies the necessary meteorological information. At Bakersfield a visual panel of ground signals gives to south-bound pilots, while in the air, information regarding the conditions in the Los Angeles area. Pilot balloons are used for ascertaining the direction and velocity of upper currents. Acting on information thus secured, the Western Air Express plane, on February 26, 1929, took advantage of a tail wind of 96 miles an hour at the altitude of 9200 feet and established a new record of 1 hour and 59 minutes between the Oakland Airport and Vail Field, Los Angeles. The heights of the cloud layers are obtained hourly by searchlights at night and by hydrogen-filled balloons by day. Telephone and teletype are used for collecting and disseminating the data, and the radio keeps pilots informed as to weather conditions while in flight. The reports are telephoned from the local substations to the collection centers, are transferred to the main line teletype system, and are available to other collecting stations and to airports within twenty minutes—truly a remarkable performance. Many interesting examples of the value of the airways weather service might be given. Thus, when a "tule fog" covers the valley, is of considerable depth, and lasts all day, air travel must be by the coast route.

The day-and-night watch over the weather; the accuracy and completeness of the available information and of the forecasts; the hearty coöperation of official meteorologists, observers, and pilots, have combined to establish conditions of safe flying which a few months ago would have seemed incredible. This system of intensive weather reporting has also proved of value to automobilists, in the sun-drying fruit industry, and in fighting forest fires. In the autumn of 1898, expert meteorological advice made it possible for a Forest Supervisor in the Santa Barbara National Forest "to herd the fire, as one would herd a bunch of sheep, directing it into a basin where it was controlled and put out." Other fields of usefulness will be found in giving advance information as to snowstorms for the use of street and engineering departments in cities; in furnishing information useful in flood forecasts, and in sending out storm warnings. Major Bowie's little pamphlet, with its many illustrations, is not only interesting but is an almost thrilling story of an incalculably valuable service.

R. DEC. WARD

EUROPE

New Maps of the Dodecanese and Their Geographical Interest. In 1922 the local government of the Dodecanese, Italy's islands in the Aegean, entrusted to the Istituto Geografico Militare the task of carrying out a topographical survey. This undertaking is now approaching completion. The results are being published in a series of maps (1:25,000) and special town plans of large scale (1:4000, 1:2000, 1:1000). The sheets on a scale of 1:25,000, which conform with but present somewhat greater detail than the Istituto's maps of Italy, are superior to existing topographic maps of any other part of the Archipelago. Owing to the inadequacy of the earlier surveys, the work has had to be done from the ground up. The modern methods employed in the astronomical determination of positions, base measurements, precise leveling, triangulation, and plane table work are described in full by Giuseppe Gianni in *L'Universo*, Vol. 10, 1929, pp. 721–766. Specimens of the maps and plans accompany Gianni's article.

In connection with the surveys many incidental data were gathered relating to geology, physical geography, and the utilization of the land. Some of this material is shown on the maps themselves, but much has been reserved for extended discussion in separate monographs. Certain problems of particular geographical interest as suggested by the maps of the island of Rhodes were outlined by the late Professor Olinto Marinelli ("La nuova carta di Rodi in relazione con alcuni problemi geografici relativi all'isola," *L'Universo*, Vol. 7, 1926, pp. 185–195).

Undoubtedly the most striking physiographic features revealed are a series of elevated terraces and cliffs, evidence of marine action during Quaternary times when sea level stood much higher than at present. These are interpreted from somewhat divergent points of view by Carlo Migliorini ("Notizie sulla morfologia di Rodi," *L'Universo*, Vol. 6, 1925, pp. 81–95) and by Professor Marinelli (*op. cit.*, pp. 189–192). As regards Rhodes, furthermore, the survey confirms the impression to be gained from earlier maps that the population is generally concentrated in villages. As possible explanations Marinelli suggests the prevalence of sheep raising and extensive farming, conditions of land tenure (communal rather than individual holdings), and reasons of security. The last surely accounts for the sparsity of settlement near the coast line.

The special town plans illustrate graphically characteristic differences between the street pattern and arrangement of houses in the various quarters of Rhodes, Coos, Leros, and other towns. In the case of Rhodes the nucleus of the town is formed by a closely compacted Moslem and Jewish settlement within the walls. It appears that at the time of the conquest the walled city was reserved by the Turks for themselves and a few Jews. The walls are encircled by a ring of Moslem and Jewish cemeteries, beyond which lie isolated suburbs. In the latter, occupied in the main by descendants of the Greeks expelled from the city, the houses are closely built on narrow streets and lanes. The modern part of Rhodes, which lies to the northwest of the walled town, has broad avenues, large public buildings, hotels, and villas belonging to rich Egyptians and Italian government officials

The Density of Population of Belgium, Luxembourg, and the Netherlands. Dr. Friedrich Leyden of Berlin has recently published three maps of Belgium, Holland, and Luxembourg with an accompanying text of fifty-four pages (Die Volksdichte in Belgien, Luxemburg und den Niederlanden in ihrer Verteilung nach den einzelnen Gemeinden und in ihren Beziehungen zur Wohndichte und zur Häuserdichte in den drei Staaten, *Petermanns Mitt. Ergänzungsheft No. 204*, 1929). The maps (1:925,000) show the density of population and number of houses to the square kilometer and the number of persons to every ten houses (Wohndichte). On each map these distributions are indicated in nine different colors on a base showing

railroads and roads in black and streams in blue. Place names are printed on transparencies which overlie the maps. While the maps are very clear and clean cut, the employment of different colors rather than gradations of one tint from dark to light is somewhat confusing. Particularly objectionable seems to be the use of a bright red, the most striking tint of all, for the median density group and of similar shades of blue for the third from the lowest and for the highest groups.

The densities of population and of houses are closely correlated with the natural provinces into which the whole region may be divided. Dr. Leyden, however, does not enlarge upon this in the text, as it has often been pointed out and is well understood. The distribution of population according to the number of inhabitants per house, on the other hand, bears a striking relation, not to physical features, but to the ethnic composition of the population. The map brings out the fact that in general there are notably fewer Walloons to a house than there are Flemings, Dutchmen, or German-speaking inhabitants of Luxembourg. The communes which have lost the most population, moreover, are those where there are fewest persons to a house. In Belgium there is very little difference between the number of persons per house in the country and in the cities; the cities, consequently, do not stand out prominently upon the map showing this distribution. Dr. Leyden observes that the visitor who looks from a high point over the industrial districts of Hainault and the region about Liége gains the impression of an almost boundless sea of dwellings. The population here, however, is less dense than in the overcrowded parts of Flanders and Brabant, where there are broad stretches of farm land between compactly built villages and towns but where average number of persons per house is greater.

Dr. Leyden's text is devoted in the main to a critical discussion of the method employed in making the maps, their accuracy, and possible applications of the method in mapping other areas. The density of population of a given area may be estimated by multiplying the density of houses by the number of persons per house. For regions where population statistics are not available the density of houses might be determined by airplane surveys and the average number of persons per house by a series of cross-section samples. With these data at hand, Dr. Leyden believes that a reasonably accurate map of the density of population could be compiled.

The average density of population of any area, particularly of a large area, is at best an abstraction. It seldom bears any relation to the density that prevails over the greater part of the area, for the concentration of population in cities will always raise the average. Obviously, therefore, the smaller the regional units for which the densities are plotted the more satisfactory the results. For the Netherlands and Luxembourg and especially for Belgium published statistics are available for very small units. This has rendered possible the construction of relatively satisfactory maps. It has also permitted Dr. Leyden to demonstrate in the text, by means of careful arithmetical analyses, precisely what pitfalls lie in the path of all students who venture upon this field of research.

AFRICA

The Centenary of France in Algeria. The year 1930 marks the centenary of French control in Algeria. Such an anniversary becomes a natural moment for stock taking. Algeria is a striking instance of official colonization in the face of obstacles that rendered private enterprise impracticable. Prosperous and well organized under the Roman Empire, North Africa had fallen into a state of utter disorganization long before the occupation of Algiers by the French in 1830. Early administrators were faced with the many problems arising from a large and hostile native population established in the best agricultural districts; from the scattered nature of the available cultivable lands separated as they are by vast mountains and semidesert; and from

a vain hope that the country could raise tropical products and thereby supplement French agriculture instead of competing with it. At the end of a century of French domination we find some 6,000,000 acres in colonization, between a third and a quarter of which represent private enterprise, and a total of 800 farm villages established. In 1926 a European population of 833,000 was composed of 658,000 French and 176,000 foreigners, largely Spanish and Italian (Augustin Bernard: L'Algérie, Paris, 1929).

The entire economic structure of the country is based on agriculture: 300,000 settlers are definitely listed as agriculturists, and the remainder are indirectly dependent upon this primary industry. Of the crops, wheat and other cereals occupy the greatest area, and these constitute the principal contribution of the native to commerce. The most important crop of the European settler is the grape; in the vicinity of Oran, Algiers, and in the Department of Constantine, vineyards on the coast, on the plain, and on the mountains dominate the landscape (Carte viti-vinicole de l'Algérie, Algiers, 1927). In fact, so extensive has this culture become that it now presents the dangers of a monoculture which is not absorbed locally and which is not a primary necessity. Other important crops consist of olives, tobacco, and fresh fruits and vegetables (see *Geogr. Rev.*, Vol. 19, 1929, pp. 328 and 331).

Although Algeria is exchanging, for the manufactured goods which she imports, agricultural products in direct competition with those of France, in French foreign trade Algeria ranks fourth in exports and fifth in imports. In 1928 the exports of Algeria amounted to 3993 million francs and her imports to 4968 million francs (see *L'Économiste Français*, 57th year, 1929, Vol. 2, No. 35, p. 259). Local traffic among the self-supporting natives is quite small. It is interesting to note that, while France has altered the methods of native exchange by means of improved communications, she has been unable to augment greatly the trade itself.

A detailed study of French colonization in a specific area is contained in "La colonisation de la Mitidja" (Paris, 1928), which Julien Franc has written in honor of the centenary. Lying to the south of Algiers between the Atlas and the Sahel, the Mitidja plain, served by railways and highways, dotted with agricultural villages both native and European, and crossed by irrigation and drainage canals, now presents the appearance of a highly specialized agricultural region. Yet, when Clouzel, the first administrator, established a model farm there in 1830 the plain was known as a place of swamps and fevers where plants either scorched under a burning sun or were flooded by sudden onrushes from the mountain streams. The military aspects of the colonization soon resulted in large, state-owned, drainage projects and in trunk highways. With the construction of these public works came large-scale private farming in contrast to the smaller, state-established agricultural settlements.

The distribution of vineyards, which cover one-quarter of the surface of the Mitidja valley, is shown on the accompanying map, on the scale of 1 : 100,000, while the many photographs both from the ground and the air go far to explain why the Mitidja is now the home of 37,000 Europeans and 80,000 natives.

The Duke of the Abruzzi's Recent Explorations in Abyssinia. Part of the run-off from the equatorial rains that fall upon the highlands of Abyssinia finds its way to the Indian Ocean by the river Juba; and part of it, following the channel of the Webi Shebeli, loses itself in marshes near the coast. Along the valleys of the Juba and Webi Shebeli alone is there much hope for agricultural development in the drought-stricken Italian colonies of Somaliland and Oltre Giuba. Since the World War the Duke of the Abruzzi has established an agricultural settlement at Shidli, where the waters of the Webi Shebeli are drawn off to irrigate fields of cotton, cereals, and sugar cane (see Renzo Meregazzi: La Società Agricola Italo-Somala, *Riv. delle Colonie Italiane*, Vol. 2, 1928, pp. 665–685). Success in enterprises of this sort depends to a large degree on the possibility of accurate predictions as to when,

each year, high and low water may be expected. Such predictions, however, can be made only on the basis of an adequate understanding of the precipitation over the little-known regions comprising the upper watersheds of the rivers. Partly with a view to studying this question the Duke of the Abruzzi in the autumn and winter of 1928–1929 conducted an expedition from Hadama (on the Jibuti-Addis Ababa railway in Abyssinia 104 kilometers from the capital) to the upper Webi Shebeli and thence down the entire length of the river (S. A. R. Luigi di Savoia, Duca degli Abruzzi: Le sorgenti e il corso dell' Uebi Scebeli, *Boll. Reale Soc. Geogr. Italiana*, Ser. 6, Vol. 6, 1929, pp. 359–371). About the headwaters it was found that there are two rainy seasons, the little rains from the middle of February to the end of March and the great rains from June to November, with a break of fifteen days in October (although above elevations of 2500 meters there is rain all the year round). Farther downstream, between Lajo and Malka Dubba, the rains are prolonged later in the spring and autumn. Below Malka Dubba the precipitation is less abundant; the Webi Shebeli, like the Nile, in this part of its course loses volume the farther it flows, largely by evaporation and partly by overflowing its aggraded banks. It receives no important tributaries in its middle and lower reaches. In Italian Somaliland water from the river may be counted on during eight or nine months of each year. There is a period of spate during the whole of May and part of June. This is followed by relatively low water until the first half of August and then by high water into November or even through December. In January, February, and March the river is always low and not infrequently goes dry in March and April.

The Duke's expedition was the first to locate definitely the sources of the Webi Shebeli. Many corrections were made in the existing imperfect maps of the river's course. At one point the stream has cut an extremely impressive canyon to a depth of no less than 1200 meters through horizontal strata and eight kilometers from rim to rim. The Moslem shrine of Sheikh Hussein was visited, an important pilgrim center, where "curious imitations of the ceremonies of the Mecca pilgrimage are intermingled with strange festivities characteristic of the paganism of the Galla folk" who conquered the shrine in the sixteenth century but, in turn, themselves embraced Islam.

ASIA

A Physiographic Interpretation of the Hwang Ho. The Hwang Ho, as explained by Günther Köhler, is one of the most interesting of composite rivers (Der Hwang-Ho: Eine Physiogeographie, *Petermanns Mitt. Ergänzungsheft No. 203*, 1929). Within its drainage basin, which includes most of northern China and northeastern Tibet, the Hwang Ho connects some seven heterogeneous regions: the eastern Tibetan Kwenlun and Nan Shan, the Chinese Kwenlun, the northern mountain rim of China, the Kansu-Shensi hill country, the Ordos steppe block, the "Rostgebirge" of Chili and Shansi, and the North China lowland. An explanation of its peculiar course must in the last analysis be based upon the geologic history of the region. Fragments of this are known, but much of it must be supplied by deduction. The whole region of eastern Tibet and northern China was once an area of anciently folded crystalline rocks, some of which still outcrop in Shantung and the mountain ranges of Tibet. Extensive areas of sandstone, shale, etc. were deposited over much of this region during the Permian and Carboniferous. During the latter part of the Paleozoic an east-west system of faults was developed, while folding occurred in the southern part of the Kwenlun and in the "Rostgebirge" of Chili and Shansi. (Rostgebirge = a mountain system of grid arrangement.) The Mesozoic was marked by partial peneplanation of the Tibetan block. A northeast-southwest system of faults also developed during the Mesozoic, and towards its close and in the early part of the Tertiary severe north-south faulting broke the region into land steps.

The most important results of these movements were the slight downsinking of the Ordos block, the subsidence of the North China lowland, and the renewed dissection of the Tibetan block.

Physiographically the Hwang Ho is consequent from its source to Sozong-gomba near the Yangtze divide, obsequent, or reversed consequent, from that point to the mouth of the Chernong River, and consequent thence to Chung-wei where it becomes superposed. From Chung-wei the river is subsequent in type, being developed along the fault zones of three sides of the quadrilateral Ordos block. From Pu-chow to the sea the river is consequent upon its own delta plain.

It is, however, the composite loess cover of North China which gives the Hwang Ho its unique position among the rivers of the earth. This immense cover of loess (Hwang-tu) was deposited during postglacial and probably interglacial time. The river, in draining this the largest region of loess in the world, may be regarded as the loess river katexochen. "From the heights of the Kwan Shan and Hsin-lu Shan, one looks down upon the huge loess land of Kansu. Like a chaotic yellow maze of summits the millionfold dissected loess extends without limit toward the north; except at one place a narrow, crooked strip of silver flashing in the sun reveals the presence of the Hwang Ho."

Köhler's morphogenetic interpretation of the river system shows the extreme youth of the yellow giant. The gaining of a lower base level during the Pleistocene inaugurated a vigorous period of downcutting, a process which is today going on rapidly throughout the entire middle and upper courses of the river. In the upper reaches, headward erosion seeks to extend the river farther back into Tibet and to tap the Kokonor and other lakes. On the other hand the Ma Chu, or upper Hwang Ho, is itself being vigorously attacked by the lower-lying Yangtze Kiang along the southern divide.

At this time the upper Hwang Ho (Ma Chu) headed much farther back in Central Asia than at present and probably discharged into the Yangtze Kiang by way of the Min Ho. The Hwang Ho probably occupied its present valley from the mouth of the Chernong River (lat. 35°, long. 100°) to Lanchow but thence reached the sea by way of the Wei Ho. The tectonic movements in the early Tertiary undoubtedly had disturbed the drainage pattern of the region enough to cause the formation of great fresh-water lakes, one of which stretched from Lanchow to Tsin (near the present source of the Wei Ho) in Kansu province. During the Pliocene mighty masses of alluvium (Queta Formation) were deposited in the broad basins of eastern Tibet and Kansu. As a result these fresh-water lakes were filled to form plains without drainage, many of them today being morasses of saturated sand and fragments of quartz and sandstone. In Kansu the marked filling in the pre-Pliocene Hwang Ho Valley between Lanchow and Tsin resulted in a central river with a terminal lake. The level of this lake gradually rose until it spilled through the mountains at Chung-wei and discharged northeastward.

During the Pleistocene the mountains of Tibet and North China were covered with glaciers which contributed great quantities of diluvium to the basins. Large fresh-water lakes, such as the Kokonor, formed along the mountain glaciers and drained into the Hwang Ho. But the great masses of glacial gravels from the eastern Kwenlun blocked the drainage of the Ma Chu toward the Yangtze Kiang and formed a new divide. As a result the Ma Chu, or upper Hwang Ho, sharply reversed its direction and finally joined the middle Hwang Ho at the mouth of the Chernong River. This enlargement of the drainage basin, coupled with the vigorous alimentation by the Tibetan glaciers, caused the Hwang Ho to reach the eastern scarp of the Ordos block and begin the excavation of its great north-south canyon from Ho-kow to Pu-chow.

In its upper course the Hwang Ho is rather closely confined by land-form structure, only the wider steppe basins permitting of local meandering or shifting of the channel.

In the middle course the river bed in the northwestern corner of the Ordos bend has within historic times migrated toward the southeast, leaving an abandoned channel still plainly defined. Most of the recent changes of channel, however, have occurred in the lower course of the river. The fact that the Hwang Ho, a veritable torrent for many hundreds of miles, abruptly emerges as the muddiest river on earth on its gigantic delta, there to wander sluggishly in a constantly aggrading channel, has made the plain of North China the classical land of river changes. From seven to ten times (during the period 2278 B. C. to 1853 A. D.) the river has shifted its course. The tributaries from the western mountain rim with their heavy loads of detritus have gradually pushed the lower river southward. The last great change, on the other hand, was back toward the north. These changes must in part be ascribed to the dike and levee construction by the Chinese, deforestation of hill land, agricultural utilization of slope land, and the monsoonal rhythm in rainfall. But by far the most important factor is the loess cover which mantles such a large portion of the Hwang Ho basin and which, in choking the lower course of the river, has earned for it from the earliest time the surname "China's Sorrow."

G. T. RENNER

Forest and Grassland in the Lena-Vilui Region. "An all but continuous night in January with its deathlike stillness, and, as a contrast, watermelons ripening under a brilliant sun in August." This is the country between the Lena and its left-bank tributary, the Vilui, in southern Yakutia. On the thermometer it means 60° C. of frost in winter and over 35° of heat in summer. The effect of this great range on vegetation is discussed by R. Abolin in "Description géographique de la végétation et des sols de la plaine Léna-Vilui" (*Travaux de la Commission pour l'Étude de la République Autonome Soviétique Socialiste Iakoute*, Vol. 10, Leningrad, 1929. In Russian with English résumé). The intense cold of winter is of little direct consequence; the important fact is the large accumulated temperatures of summer—large for a latitude between 60° and 64° N. The warm season is but little shorter than in parts of central Siberia, Chita, and Irkutsk, much farther south. The northward swing of the May, June, July isotherms about the area is striking (see W. B. Schostakowitsch: Contributions à l'étude de climat de la république Iakoute et des pays contiguës de l'Asie septentrionale, *ibid.*, Vol. 6, 1927. Text and Atlas. Text in Russian with German résumé). So is the low degree of cloudiness for the summer months. And not less striking is the low yearly rainfall, 200 millimeters, a figure similar to that for the Kirghiz steppes.

Under the combination of low rainfall and high temperature semiarid vegetation might be expected. On the contrary, before the intervention of man the region was covered with "a continuous canopy of forest." Explanation is to be sought in the indirect effect of the winter cold, which results in a permanently frozen subsoil, "a most beneficial apparatus for the conservation and very economical consumption of water." The natural landscape has, however, been radically transformed in the last few centuries. When in the mid-seventeenth century the cattle-breeding Yakut began to replace the reindeer-breeding Tungus, destruction of the forest also began in earnest. The meadows now dot oasis-like the surface of the nearly flat plain. They are particularly associated with depressions—because of the more combustible nature of the original vegetative cover—but from thence the grassland is spreading in the form of "gigantic tentacles" into the virgin *taiga*.

The future of this section of southern Yakutia may lie in agriculture. So far it has made little headway with the Yakuts. But that cereals can be successfully grown is proved by the crops of the Russian settlers, barley and rye, wheat and oats, in the larger river valleys. In a land so near the margin of cultivation the selection of seed and soils is peculiarly critical, and organized assistance and education will be necessary if the pastoral Yakuts and their grasslands are to be won over to crop production.

THE OCEANS

The Currents in the Strait of Gibraltar. The predominant movement of the surface waters in the Strait of Gibraltar from the Atlantic into the Mediterranean has been known to the mariner for many years. Modern oceanographic research has developed many facts which find readiest explanation in a predominant subsurface current from the Mediterranean into the Atlantic. The existence of these two currents, an upper one setting easterly and a lower one setting westerly, had been generally accepted. Recently, however, the Spanish oceanographer Dr. Rafael de Buen challenged the correctness of this explanation. In the "Rapport Atlantique 1927" (*Rapports et Procès-Verbaux des Réunions, Conseil Perman. Internatl. pour l'Expl. de la Mer*, Vol. 55, pp. 50–110) he develops the theory that the westerly-setting subsurface current becomes deflected upward and, near the entrance to the strait, is turned back toward the Mediterranean by the easterly-setting surface current, so that no Mediterranean water reaches the Atlantic.

In a comprehensive study under the title "Die Wasserbewegungen im Gebiete der Gibraltarstrasse" (*Journ. Conseil Perman. Internatl. pour l'Expl. de la Mer*, Vol. 3, 1928, pp. 139–175) Dr. Gerhard Schott discusses the observational data bearing on the oceanographic conditions in the Strait of Gibraltar. From this study it appears that de Buen's thesis is untenable. Schott finds the movements of the water here complicated by the existence of well developed currents of three types—tidal currents, subsurface currents, and surface currents. The tidal current extends from the surface to the bottom and alternately floods and ebbs in periods of about six hours with a velocity at strength of a little over a mile an hour, or one knot. Superimposed on this regular tidal current is a surface, or, more accurately, an upper current setting from the Atlantic into the Mediterranean with a velocity that varies with the wind but on the average is a little over half a knot. Below the surface is a compensatory current setting from the Mediterranean into the Atlantic.

The surface and subsurface currents are of especial importance here, for they transport water masses of different character. The surface current carries the less saline water of the Atlantic into the Mediterranean. The subsurface current carries the highly saline water of the Mediterranean out into the open ocean, and its influence is felt over a wide area as far north as Ireland. The boundary between the surface and subsurface currents is subject to a seasonal variation. In summer it lies about 200 meters from the surface, while in winter its depth is only about 100 meters.

In addition to this seasonal fluctuation in the boundary between the two layers of water, Schott directs attention to the existence of fluctuations with a period of about half a day. These so-called internal waves have a range of as much as 80 meters and appear intimately connected with the tidal movement. With such a large range it is clear that due consideration must be given these vertical oscillations in evaluating oceanographic data secured in the strait at any given depth that falls within the limits of the fluctuations.

H. A. MARMER

Sea Level in Relation to Form of Shore Line. In studying coastal stability the accurate determination of mean sea level is a primary consideration; for the emergence or subsidence of the coast manifests itself and is measured in relation to sea level. The most obvious and most regular agency disturbing sea level being the tide, the rise and fall of which has a period of approximately half a day, it was at first assumed that averaging the varying height of sea level over a number of days would eliminate the effect of the tide and result in an accurate determination of mean sea level. Later it was found that there are seasonal variations of sea level, and more recently it has been shown that even from year to year there are fluctuations in sea level.

All these variations in sea level, however, were considered as due to forces acting

directly upon the waters—the tidal forces, wind, weather, and the like. But may not changes in sea level take place in response to changes in form of shore line? This question has been raised by Professor Douglas Johnson. The elevations of the high- and low-water lines within any embayment of the coast are very markedly affected by changes in hydrographic features. May not sea level, too, be affected?

In "Studies of Mean Sea-Level: Report of the Committee on Shoreline Investigations, National Research Council" (*Bull. Natl. Research Council No. 70, 1929*), Professor Johnson elaborates the thesis that "along an irregular coast the mean sea-level surface is an irregularly warped plane which is extremely sensitive to alterations of the form of the shore, depths of tidal channels, and other shore features" and reports on tidal studies in the region around New York undertaken to test the theory. These tidal studies, carried out principally in Jamaica Bay, were made with two purposes in view. The immediate purpose contemplated "intensive studies over a comparatively short period of time . . . for the purpose of determining the *form* of the mean sea-level surface as affected by the form of the shore combined with the influence of outflowing rivers, prevailing winds, and other factors." At the same time the results derived would furnish the necessary data for determining, by comparison with later observations, whether or not the coast had emerged or subsided.

The observations in Jamaica Bay comprised continuous tide observations at three stations over a period of 16 months. These observations were made with due attention to secure precise data and were tied into the precise-level net that covers the New York region. The results of these observations are given in detail and furnish valuable data for the tidal student. As regards the more immediate purpose of the study, these observations show that within the bay the plane of mean sea level is not level but is higher at the head than at the mouth, though the difference is but a tenth of a foot. Furthermore, sea level in Jamaica Bay was found to be higher than at Fort Hamilton in the entrance to New York Harbor, this difference being between one-tenth and two-tenths of a foot. In interpreting these results, Professor Johnson concludes that "it seems reasonable to believe that much greater distortions of the mean sea-level plane must exist at many points along our coast, while smaller but appreciable distortions may be expected in some of our bays and harbors widely open to the sea."

As regards the second purpose of these studies, Professor Johnson directs attention to the fact that tidal studies of this kind "form the best obtainable basis for testing the theory of a progressive general submergence or emergence of a coast." After the lapse of a number of years similar studies made at the three stations in Jamaica Bay will furnish conclusive evidence whether or not there has been any change in the relation of land to sea. "Today we are unable to make such a determination for the Atlantic Coast, covering any long period of time, because the supposed changes are slow as to rate and small as to amount, and our predecessors of half a century ago failed to make observations of sufficient precision to serve as a reliable basis of comparison. We at least shall hand on to our successors data which are of far greater precision than any at our disposal and which, so far as we can determine in the light of our present knowledge, will be adequate for the purpose in view."

H. A. MARMER

GEOGRAPHICAL NEWS

Grants-in-Aid of the Social Science Research Council. The Social Science Research Council announces its second annual list of Grants-in-Aid (1929). Altogether, thirty-seven scholars received support. On the basis of major emphasis their projects were distributed among the social sciences as follows: Anthropology 2, Economics 6, History 16, Political Science 2, Psychology 4, Sociology 5, Human Geog-

raphy 2. Most of the projects, needless to say, straddle a number of these fields. In fact, while not insisting upon it, those administering Grants-in-Aid look with favor upon projects that represent a broader approach to a problem than is possible within the limits of any one discipline. The Grants-in-Aid in Human Geography were awarded to: Oscar Schmieder (University of California) for the project "Examination of the Persistence of Indian Institutions in Land Utilization and of the Effect of Spanish Influence on Types of Human Settlements, Field Pattern, and the General Cultural Aspect of the Valley of Oaxaca and the Adjacent Mountains of the Mixe"; George B. Cressey (Shanghai College) for the project "The Geography of China."

The aid granted by the Council ranges from $200 to $2000 and, in almost every case, is conditional upon liberal coöperation from the institution with which the applicant is connected.

The administration of Grants-in-Aid is in the hands of a special Committee of the Council known as the Committee on Grants-in-Aid. The Committee plans to hold two meetings during the coming academic year, in mid-November and in mid-March. The closing date for receiving applications for consideration at the latter meeting is February 1, 1930. Any scholar who is a resident of the United States or Canada and who has evidenced real research ability is eligible. The Committee expects that the applicant's project will be well under way, that he can forecast the time and the money required to complete it, that it is not to be used in fulfillment of any higher academic degree, and that he has already canvassed carefully the possibility of aid from his own institution. Applications should be addressed to Walter R. Sharp, Secretary of the Committee on Grants-in-Aid of the Social Science Research Council, 230 Park Avenue, New York City.

Pan American Institute of Geography and History. The first general Assembly of the Pan American Institute of Geography and History was held in Mexico City from September 16 to September 22, 1929. There were representatives present from 17 American countries, each of which is a member of the International Conference of American States. Delegations were expected from Chile and Guatemala, but difficulties of transportation prevented them from reaching the Assembly before its adjournment. Argentina and Venezuela failed to appoint or send representatives.

The Pan American Institute of Geography and History was authorized at the meeting of the Sixth International Conference of American States held in Havana, Cuba, in the early part of 1928. For many years geographers and historians of the American nations have felt the need of some association or institute which could assist in correlating the work of the American countries. This is really the purpose aimed at in the foundation of the Institute.

Statutes approved by the representatives present in Mexico City provide for the officers and for the quotas to be paid by the different American countries. Provision was made for the office of the Director, which will be located in a building now under construction by the Mexican government in Tacubaya, D. F., Mexico, on a site next to the office building of the Estudios Geográficos y Climatológicos. Professor Pedro C. Sánchez, the Director of the latter institution, was elected Director of the Institute. The president of the Institute is Professor Salvador Massip of the University of Havana. Two vice-presidents and a number of alternates were elected as well as two honorary presidents, Dr. José Toribio Medina, Chilean historian, and Dr. William Bowie, of the U. S. Coast and Geodetic Survey.

Provision was made in the statutes for the appointment of a national committee on geography and history for each of the adhering countries. Presumably these committees will not be appointed or begin to function, if appointed, until after the ratification of the action taken during the Assembly at Mexico City.

The Assembly was opened by the Secretary of Agriculture and Public Affairs, as the representative of the President of the Republic of Mexico. An address was given

by the Governor of the Federal District. The closing session was held in the National Palace, where the President received the delegates to the Assembly of the Institute.

The three representatives from the United States were Colonel Lawrence Martin, chairman of the delegation, representing the Library of Congress and the State Department, Professor George Beverly Winton of Vanderbilt University, and Dr. William Bowie, representing the National Geographic Society and the Department of Commerce. It is expected that a printed report of the proceedings of the Assembly will be distributed in the near future.

WILLIAM BOWIE

OBITUARY

HERMANN WAGNER. Hermann Wagner, emeritus professor of geography at the University of Göttingen and dean of German geographers, died at Bad Wildungen on June 18, 1929, in his eighty-ninth year. With him has passed away the last of that small group of necessarily self-trained men who in the seventies of the last century laid the foundation for the development of modern geography in Germany.

Wagner's early leanings were toward mathematics and physics, and even his doctor's thesis in 1864, on the surface measurement of the brain, although influenced by his father's position as professor of physiology at Göttingen as successor to Blumenbach, revealed the quantitative and mensurational bent that characterized so much of his later work. But it was the call to a teaching position at the *gymnasium*, or high school, at Gotha, which he occupied from 1864 to 1876, that turned him definitely toward geography. Here he soon was in intimate contact with the establishment of Justus Perthes, which, under the scientific directorship of August Petermann, had become the leading clearing house of geographical information in Europe. Here, too, was laid the foundation for his specialization in cartography—an outgrowth of his conviction that the map is the fundamental and distinctive tool of geography. His statistical interest found expression in the editorship of the statistical section of the Almanach de Gotha, which he assumed in 1868, and of the "Bevölkerung der Erde," the recurrent critical compilation of population data of the world, of which he edited seven issues between 1866 and 1891.

It was the realization, while he taught mathematics, natural science, and geography at the Gotha *gymnasium*, that the low estate of geography was mainly due to the inadequacy of the training offered, that made him the champion of geography as a university subject. In spite of its early climax under Humboldt and Ritter, geography was languishing at that time in Germany as an academic discipline. Only five or six chairs of geography existed, of which three were in Prussia, and these represented a narrow conception of the subject. But mainly as a result of Wagner's endeavors, in which he was seconded by Alfred Kirchhoff and Alexander Supan, full professorships were established in 1874 at the other six universities of Prussia. He himself was appointed to the chair at Königsberg, where he stayed until 1880, when he was offered the chair at Göttingen, which he accepted and continuously occupied until his retirement in 1920, in spite of flattering offers from other universities. In the course of these forty years he built up a department of geography that counted among the three or four leading ones in the country. Through his hands passed literally hundreds of students, the majority of them prospective secondary and high school teachers—for in the German educational system practically the same training is required of the teacher at an upper school as of the candidate for a doctor's degree, a circumstance to which is mainly attributable the scientific attitude of mind that characterizes most of the teaching profession in Germany.

Among Wagner's pupils there were, however, of course a not inconsiderable number who planned to devote themselves to research or to an academic career. That in the forty years only about three dozen doctor's degrees were awarded in the

department is evidence of what his standards were. In his courses he himself covered the whole subject matter of geography, alternating every semester between one of the three major subdivisions of general geography—mathematical, physical, and human geography—and the regional geography of one of the continents or of Germany. Only during the last fifteen years of his tenure was his task lightened by a younger associate. The systematic body of knowledge which he had thus developed from the ground up he laid down in his well known "Lehrbuch der Geographie," probably the outstanding scientific presentation of the whole range of general geography in any language. Only six years ago he completed the revision of the fifth edition. In the field of regional geography he published in 1915 a geography of Europe which is the first instalment of a regional treatise conceived in the same spirit as the "Lehrbuch" which, it is announced, will be continued by his successor at Göttingen. His "Methodischer Schulatlas," of a more advanced type than its title implies, has passed through sixteen editions.

Another life-long undertaking was his editorship of that indispensable tool of bibliographical research, the *Geographisches Jahrbuch*. From his assumption of the office in 1879 to the last stroke of his pen in correcting proofs on his deathbed he edited 36 volumes, contributing to the earlier volumes, when geography was still in a formative stage, an important series of articles on the methodology of the subject. Among other publications revealing his critical analysis of the problems involved may be mentioned his reconstruction of Toscanelli's map (1894) and his papers on the history of the nautical mile (1913) and on the development of nautical science at the beginning of the Age of Discovery (1918).

The American Geographical Society's relations with Professor Wagner date more especially from 1910, when the Cullum Geographical Medal was awarded to him (*Bull. Amer. Geogr. Soc.*, Vol. 43, 1911, pp. 52 and 283–284). The "Aids to Geographical Research" in the Society's *Research Series* benefited from his reading of the manuscript; and on its part the Society was happy to be instrumental in restoring the relations, interrupted by the war, between the *Geographisches Jahrbuch* and the *Bibliographie Géographique*, the two standard bibliographies, each of which reflects its national genius and so admirably supplements the other.

A biography of Wagner, by Professor Wilhelm Sievers, one of his pupils, appeared during his lifetime in the *Geographen Kalender* for 1908. Five years before his death he wrote a valuable autobiographical sketch (Göttinger Professoren: Lebensbilder von eigener Hand, *Mitt. Universitätsbund Göttingen*, Vol. 5, No. 2). An article on the work in geography at the University of Göttingen (*Geogr. Zeitschr.*, Vol. 25, 1919, pp. 1–20 and 97–106) is, as he terms it himself, the account of his stewardship. A sympathetic obituary by his successor, Professor Wilhelm Meinardus, appeared in *Petermanns Mitteilungen*, 1929, No. 9–10, pp. 225–229, and a memorial by a Dutch pupil, Dr. J. F. Hoekstra, contains personal touches (*Tijdschv. Kon. Nederl. Aardrijksk. Genoot.*, Series 2, Vol. 46, 1929, pp. 821–827). A list of his publications to 1920—273 items—will be found in *Petermanns Mitt.*, Vol. 66, 1920, pp. 118–122.

GEOGRAPHICAL REVIEWS

Australian Problems

P. D. Phillips and G. L. Wood, edits. **The Peopling of Australia**. xi and 300 pp.; maps, diagrs., index. (Pacific Relations Series, No. 1.) Macmillan & Co., Ltd., Melbourne, 1928. 6 s. 7½ x 5 inches.

Persia Campbell, R. C. Mills, and G. V. Portus, edits. **Studies in Australian Affairs by Various Writers.** Issued by the Institute of Pacific Relations, New South Wales Branch. 269 pp.; maps, index (Pacific Relations Series, No. 3.) Macmillan & Co., Ltd., with the Melbourne University Press, Melbourne, 1928. 6 s. 7½ x 5 inches.

These two volumes are the respective contributions of the Victoria and the New South Wales branches of the Institute of Pacific Relations to the study of Pacific problems. Eleven authors have collaborated in the production of the first-mentioned book. The discussion ranges widely from immigration and the workings of the Australian labor-union and economic system to the climatic limitations of the continent—the deficient rainfall on the one hand and the high temperatures and humidities of the tropical northern portion on the other. It is clear from the arguments, sometimes contradictory as among the several papers, that almost every phase of Australian life is in a highly experimental stage today. Labor unions insist upon selective and restricted immigration with little concern over the slowing down of the rate of development of the agricultural and pastoral lands since their eyes are fixed upon the higher standards of living that have had such beneficial effects in diminishing the infant mortality rate and lengthening the "expectation of life." Nor does assisted immigration and the maintenance of high standards of living solve the problem: almost as many people moved from country to city in Victoria in the five years 1922–1927 as entered the state under Closer Settlement Schemes during the long period from 1904–1928. After two years and the settlement of 1350 assisted migrants upon the land in Western Australia, the scheme was slowed down almost to the stopping point because the farms cost about 50 per cent more than the market value of the land after it had been cleared and buildings erected.

One author concludes that about all the arable land has been staked out and that an extension of the tilled land is difficult if not impossible because of the higher prices that pastoral products will bring. Some interesting comparisons are made between the amounts of land required to supply an average adult with flour and meat. To satisfy one man's need for meat in Australia—216 pounds per head per annum—requires sheep and cattle grazed upon 5.2 acres of land under 15 inches of rain. To satisfy the average man's consumption of wheat—5 bushels per annum—requires only a third of an acre with a rainfall of about 15 inches (on a farm in Victoria). If sheep were raised in the same district in which wheat is grown it would require 5.5 acres under 15 inches of rain to keep one adult in flour and meat for one year.

The critical importance of rainfall is seen in a table which shows the relation of increased rain to increased crop in Victoria. One inch of rain in August or September "produces" 8.22 bushels per acre, 2 inches in the same months 11.87 bushels, 5 inches 16.46 bushels. The number of sheep per acre that may be carried in range country is approximately 4 per cent of the annual rainfall given in inches, that is, 25 inches of rain will support one sheep to the acre. All such relations may be progressively improved by the use of fertilizers, new strains of wheat, better tillage, and the rotation of cultivated land and pasture.

The conservatism of Professor Griffith Taylor in estimating future population and in definitely recognizing the territorial limits of close settlement in the dry interior of the continent is vindicated. No one among these authors assumes the earlier fantastic limits of population capacity in the interior, and every effort is made to correct the wrong assumptions of the politicians who suppose that because Australia is as large as the United States it is as richly endowed with natural resources and may ultimately have as large a population. The advocates of white settlement in tropical Australia have their advocate in H. W. Cilento, who contributes Chapter 9 and who vigorously attacks all of the arguments that support the conclusion that tropical Australia is incapable of successful white settlement on a larger scale. Although his argument is cleverly constructed, it flies in the face of a mass of testimony that can have but one meaning. It is not enough to demonstrate the health of the inhabitants and their physical capacity to stand the high temperatures and humidities of the northern tropical zone. A far more important question, which is overlooked by Dr. Cilento, is the matter of comfort and tolerability.

Twelve authors contribute to "Studies in Australian Affairs." From economic, social, and political angles they shed light on the development of a pioneer state, "a young community in a continent of vast area far removed from the world centers of financial and commercial activity." The experimental stage in which the country finds itself is illustrated by the tariff situation which J. B. Brigden describes as "unique." We quote from him a final paragraph.

"In the last resort the problem becomes one of economic geography, and in this, as in the other subjects mentioned, we can take nothing for granted if we are to deal with this stubborn problem in a scientific spirit. Australians have been accustomed to taking their economic geography very much for granted, and the scientific spirit as represented by Professor Griffith Taylor has for many years past been like a voice crying in a babel of sound about 'potentialities.' Our rich coastal fringe and the sheep stations further inland have been rich enough to bear the costs of assisting both primary and secondary industries, but what lies beyond the frontiers? Obviously not land rich enough to carry the costs borne by the land at present used. Is it rich enough, in soil and climate, to have taken the place of the protected industries, if it had been free from their costs? A partial answer is supplied in this book by Professor Griffith Taylor, who, however, limits himself mainly to climatic considerations."

The British Empire

J. H. Rose, A. P. Newton, and E. A. Benians, edits. **The Cambridge History of the British Empire, Vol. 1: The Old Empire from the Beginnings to 1783.** xxi and 931 pp.; bibliogr., index. The Macmillan Co., New York; Cambridge University Press, Cambridge, England, 1929. $9.50. 9½ x 6½ inches.

This massive volume, written by nearly a score of men learned in their subjects, is concerned chiefly with early English effort in the West Indies and on the continent of North America. One says English advisedly, for the Irish and the Scots had but slight part in the creation of the colonies that have expanded into the United States. Their turn came chiefly in the nineteenth century when they spread all over the English-speaking world. Geographical position had much to do with this English expansion. Scotland was too far to the north, Ireland too remote from continental Europe, to be in the chief currents of commerce. It is a truism indeed to say that the British Empire of today is the child of geography. As early as the fifteenth century and markedly in the sixteenth century the English complained of overpopulation. To us the three million English and Welsh of the year 1500 seem few for so large an area, but it was almost purely agricultural, and many larger and quite fertile agricultural sections in both the United States and Canada have even now fewer people. The English felt urgency to expand. For this they fought during

a hundred years to master France. When they failed to do so, in the fifteenth century, they pressed southward, westward, and northward and have kept up the process ever since.

The present is the first of eight volumes in the series: we shall have two more on British expansion and the history of the less important divisions, now alone colonies; three on the self-governing Dominions; two on India. This volume is learned, adequate, and very solid. Coöperative history has the advantage of highly specialized authors for each section; it has the disadvantage of lack of unity in style and of involving almost necessarily a certain amount of repetition. The present authors are chosen from a wide range of interests. The names of Professor C. M. Andrews, Sir Charles Lucas, Dr. J. Holland Rose, Professor A. P. Newton, Mr. Cecil Headlam, Dr. H. W. V. Temperley, and others of the writers are widely known. Copious footnotes relating to both printed and unprinted material reveal independent research. The topics cover the whole field of English effort from the days before Cabot to the creation of the United States. The Elizabethan struggle with Spain, early colonization in Virginia and later efforts, the effect of the Puritan struggle in England on America, international law as affecting the view that not merely discovery but effective occupation gave ownership, imperial policy, England's control of colonial trade, the growth of slavery, and a dozen other topics are treated. Nearly half the volume is given to the Seven Years' War and the American Revolution and covers topics such as sea power, mercantilism, Parliament's supremacy over the colonies, and military operations. Though precision of fact is more evident than imaginative insight, the reader always feels that the writers have mastered their subjects.

The only European people who have in any wide sense created and ruled oversea communities of their own blood are the British. Though indeed Spain mastered a large part of America, comparatively few Spaniards migrated. Unlike the English and the French, the Spanish were from the first conquerors; and their possessions were dependencies rather than colonies peopled from Spain. The Dutch were traders but bad colonizers; few of them went to live outside Holland. After the English had beaten both the Spaniards and the Dutch in the colonial field and had France as chief rival, their ultimate victory was inevitable because they had sent out about a hundred to settle in North America to one sent by France. It is doubtful whether as many as ten thousand settlers went to the only great colony ever founded by France—Canada. Rarely have the French willingly left France. Germans and Italians might have founded colonies, but their national union came too late for colonies with political ties in Europe.

Climatic influences ultimately deterred and limited English colonizing effort. Though the English were victors in the long struggle with Spain, little of the British Empire of today was taken from Spain. She had occupied wide tropical and semi-tropical regions where climate forbade extensive European colonization. Even when Oliver Cromwell took Jamaica, the English did not really colonize it. They brought in a slave population to do the field work, but few whites went to live in Jamaica. When sugar became the principal product in the British West Indies, the relation was more and more that of a few masters over a slave population; the climate caused the owners of estates to go when they could to live in England and by so much to weaken any real colonization. The same climatic reason has kept empty the tropical regions of British Australia. Thus geography has dictated conditions in the founding of empires and remains the potent master of their expansion.

In days before the definition of the three-mile limit England claimed the sovereignty of the narrow seas which washed her shores and tried to force the Dutch who sailed them to salute their flag. In an interesting chapter on the growth of international law in respect of maritime rights, Mr. A. Pearce Higgins traces the narrowing down of such wide claims to the acceptance of the three-mile limit, with which are con-

nected not only claims to blockade but also the rights of neutrals on the high seas, an urgent international problem of the present day. One of the most interesting chapters, that by Eveline C. Martin, deals with the English slave trade. The author quotes an eighteenth-century opinion that it is "an inexhaustible Fund of Wealth and Naval Power to this Nation" (p. 437). She ridicules the belief that slaves were secured by kidnaping the inhabitants of the coastal districts of Africa. The slaves were brought to the coast by Moorish traders, sometimes for a distance of eleven hundred miles. It was by this commerce that European commodities were secured for the distant interior of Africa. And by it also Bristol and Liverpool grew to importance.

The volume is a mine of information on every aspect of colonization during the period covered. In form and substance it is a credit to both publishers and authors.

GEORGE M. WRONG

THE NATURE AND SCOPE OF GEOGRAPHY WITH ILLUSTRATIONS FROM FINLAND AND ESTONIA

J. G. GRANÖ. **Reine Geographie: Eine methodologische Studie beleuchtet mit Beispielen aus Finnland und Estland.** ix and 202 pp.; maps, ills., bibliogr., index. *Publs. Inst. Geogr. Univ. Aboensis No. 3*, Helsingfors, 1929.

This philosophic discussion of the nature and scope of geography presents not only a summary of the views held during the past half century or more, but a number of stimulating new conceptions. Coming from the pen of an outstanding Finnish geographer who has been at work in a country where the economic and other human aspects of the science have been given, until quite recently, relatively slight consideration, the arguments and conclusions are particularly arresting.

Dr. Granö states the purpose of his treatise to be an attempt to demonstrate that "man's environment, as a material and visible complex of phenomena, constitutes the fundamental objective in geographic research." He proceeds then to engage in an analysis of the objectives and possible modes of approach. Since the establishment of a systematic terminology to aid in accuracy of description and the cartographic representation of geographic phenomena are considered by the author to be of primary importance, he attempts to work out both of these elements. His discussion contains numerous fascinating details, many of which would no doubt arouse any group of geographers to a lively controversy. However, an attempt will here be made to present only a few of what seem to be the major conceptions.

The environment, geographically considered, falls into two main categories, namely, "die Nähe," which may be freely translated as the foreground, of any outdoor area which one views and "die Landschaft," the landscape itself. The foreground is limited to a distance of perhaps 20 to 50 meters or farther from the observer, according to his elevation above the immediate surroundings. This area lies between the observer and a line marking the maximum distance from him at which all of the visible objects are seen in their true or absolute proportions. The region between the outer limit of the foreground and the horizon, or as far as the eye can see, is the landscape proper.

Landscapes are varied in character, but they may be classified into *open* and *closed* types, both of which are illustrated, the former represented by a view across a plains area with no obstructions in it and the latter by a view along a valley interrupted by a mountain wall which blocks out the horizon. Within each of these landscapes the factors of spacial relations and time must be recognized. These in turn involve the recognition of mobility and immobility, in the sense of shifts in position, and changeable and unchangeable qualities as regards the form of material things.

For example, man and animals are considered mobile but unchanging, whereas vegetation may be immovable but changeable in form with the successive seasons.

In his subsequent analysis of the landscapes and their cartographic representation Granö seems to observe an almost limitless number of elements in an environment, each of which may be represented exclusively of all the others. So he notes and illustrates respectively the landscapes of (1) land forms, (2) water forms (in summer appearance), (3) vegetation (in summer), (4) settlements according to their plan and size, the arrangement of buildings, and the density and character of highways, (5) color, (6) light and moisture, (7) sound, (8) odors, and (9) the character of the "substratum," that is the surface upon which the landscape is built or out of which it rises. This last type includes such items as firmness of the surface with respect to the weight it will support, the angle of slope, moisture, air temperature, disturbing elements such as earthquakes, and "obstacles" by way of snow, ice, water, or vegetation. Even the mobile forms of the air are considered in a category which includes dust, cloud, fog, rain, flying animals, airplanes, and the mirage. Then, too, "rhythmic changes" may be portrayed, such as changes from a snow covering to the low green vegetation, from bare trees to trees in full leaf, from flooded lands to dry lands.

Having analyzed the landscape, Dr. Granö reverses the procedure and synthesizes the analyses, for he argues that geography deals with units and therefore the parts need to be related. He maps each landscape and superposes them to produce the natural region. But here are numerous possibilities. The conception of a natural region may vary according to differences in the objectives or viewpoints of different investigators. Accordingly, the eight or ten maps of the analysis need not all be synthesized at one time; but combinations of several may be worked up into different types of maps, each emphasizing a limited number of features. According to the author, a natural region must be characterized by homogeneity; but every element in a given area need not be incorporated within a natural region map. In fact no agreement exists among geographers as to what elements compose a natural region. Dr. Granö illustrates his regional concepts by cartographic applications from Estonia and the small island of Valosaari in Saima, a basin in southeastern Finland not far distant from the city of Mikkeli.

The study is followed by a summary consideration of the scope of geography. The author conceives geography to be very broad and to include studies not only of the tangibles but also of the intangibles such as religion, language, art, and the like. Although he believes geography to be a science that deals distinctly with the problems and materials of the present rather than the past, nevertheless the findings of the present may be applied to situations of the past. Geography demands both a description and an interpretation of the complex phenomena associated with the earth's surface, description having a place of great importance.

A bibliography of 303 titles offers a wealth of source material to those interested in pursuing a study of the scope and nature of the science.

EUGENE VAN CLEEF

DISTRIBUTION OF POPULATION IN ESTONIA

AUGUST TAMMEKANN. **Outlines of the Distribution of Population in Estonia.** 8 pp.; maps, bibliogr. *Publs. Inst. Univ. Tartuensis Geogr. No. 16*, Tartu, 1929.

This brief discussion is accompanied by a detailed population map made on the dot method. The dots are spheres after the manner introduced by Sten De Geer in his population map of Sweden. The cartographic method itself is interesting, yet in this instance it is of less consequence than the information which the resultant map reveals.

Three facts are especially worth noting on the map, namely, the dominant rural character of the country, the relatively even distribution of the population, and the

location of the rural population in the interstream areas. The last observation is particularly significant.

The author explains the evenness of distribution largely upon the basis of soil and uniformity in topography. The post-war disintegration of large estates also has exerted an incidental effect. However, no explanation is offered for the absence of concentrations along many streams while divides and isolated areas are occupied. This situation is not unlike that in many parts of Finland. Estonia being largely Finnish in character, the Finnish temperament is recognizable. These locations seem to be in large part a response to the Finnish desire for individual independence. Furthermore, the protective advantages of knolls or hilltops and to some extent their relative freedom from frost undoubtedly has influenced location.

EUGENE VAN CLEEF

THE PLATEAUS OF THE CENTRAL JURA

GEORGES CHABOT. **Les plateaux du Jura central: Étude morphogénique.** 350 pp.; maps, diagrs., ills., bibliogr. (Publs. de la Faculté des Lettres de l'Université de Strasbourg, fasc. 41.) Soc. d'Édition: Les Belles Lettres, Paris; Humphrey Milford, Oxford Univ. Press, 1927. 50 frs. 10 x 6¼ inches.

According to this detailed morphogenetic study, laborious alike in its preparation and its reading, the western or plateau area of the Jura mountains is chiefly a peneplain, formed by subaerial erosion on moderately deformed strata, mostly limestones; but the peneplain is much dismantled by later erosion, as if in consequence of two moderate upheavals, and is still further modified by deeper erosion consequent upon renewed upheaval and deformation. A typical area of the main peneplain, known as the plateau d'Ornans (which, for the sake of those who like to locate natural features with respect to neighboring cities, may be said to lie midway between Besançon on the lower land to the west and Pontarlier in one of the mountain valleys to the east) has a medial altitude of 600 or 650 meters; but, because of a sub-cycle of partial degradation as well as because of the later deformation, its southwestern or Trépot part is as low as 540 meters, while its northeastern or Vercel part reaches 700 meters, the two parts differing in altitude by 20 or 30 meters at their junction and being separated by a gentle westward slope that follows a very irregular course. The main valleys, incised in consequence of the latest elevation of the region, greatly interrupt the original continuity of the now high-standing, two-phase peneplain. As a result of the abundance of limestone a good number of the shorter valleys are "blind," in the sense of being closed at the lower end where the stream disappears underground; sink-hole hollows also abound. These special features are discussed in a final chapter on the karst problem.

Like many other studious monographs, this one is difficult to read understandingly; not so much because of any inherent difficulty of its problems, but rather because of the apparent indifference of the author to the "honorable ignorances" of his distant readers. Insufficient care is taken to present significant features in general terms, independent of purely local items. Furthermore, the progress of the text is slow; too many introductory pages must be read through in successive chapters before the relatively simple conclusions that the painstaking author has reached are briefly announced. A number of good half-tone views and several detailed maps ornament the volume, but the text figures are disappointing: they are mostly mere profiles, several of which are so much reduced from the original drawings that the meters of altitude are hardly legible. In consequence of these shortcomings this valuable monograph will receive less attention than it deserves. In particular it will, in spite of having been prepared under the direction of the four leading geographers of France, not greatly affect the geographical description of the Jura, because

it is avowedly morphogenetic; that is, it elaborately treats the conditions and processes under which the Jura plateau was produced, but it nowhere gives a succinct physiographic account of the produced features ready for easy use by other geographers.

W. M. DAVIS

RAINFALL AND FOREST PROBLEMS IN CHILE

OTTO BERNINGER. **Wald und offenes Land in Süd-Chile seit der spanischen Eroberung.** 130 pp.; maps, ills., indexes. *Geogr. Abhandl. herausg. von N. Krebs*, Ser. 3, 1929, No. 1. J. Engelhorn, Stuttgart.

WALTER KNOCHE. **Jahres-, Januar- und Juli- Niederschlagskarte der Republik Chile.** *Zeitschr. Gesell. für Erdkunde zu Berlin*, 1929, No. 5–6, pp. 208–216.

Otto Berninger takes up the question of change in the distribution of woodland in the *Frontera* in historic times. Was this area, the northern limit of the forests of southern Chile, originally forested; or did the woods result from the wars, overgrowing open lands that the Araucanians had earlier inhabited? He concludes that there have been but moderate changes in the forest since the Spaniards came, nor so very much since the beginnings of the newer colonization of 1850. Woods have been cut away in the drier central valley. That is well known. Also from the shores of the Gulf of Reloncavi and in to Osorno. But the total area so cleared is not great. The delineation of the forested part of Chile has not altered very much. On the other hand in a good many places there have been small advances of the woods over the open ground. Superstition of the Indians brought this about on spots where Spanish settlements had been destroyed, as at Tucapel, where Valdivia lost his life. The Indians would not build on such spots, and they grew up to woods. One type of forest, the Continental Summer Woods, has a number of expansions—the open lands of the *roble*. The Araucanians, or Mapuches, as they call themselves, have always been dwellers in forest glades.

As a preliminary to the detailed investigation, physiography, rainfall, and forest types of the region are considered. For the rainfall, Berninger regards as demonstrated the greater dryness of the central valleys, which this reviewer pointed out in Research Series No. 7 of the American Geographical Society, the "Rainfall of Chile," in 1921. "The view of Pissis [Geografía física, p. 207], which Hann too adopted, that the region south of 37° had extraordinarily uniform rainfall, can no longer be maintained."

But Berninger quotes as preceding the "Rainfall of Chile" in this view, a map by Edwards and Knoche, printed in 1920, belonging "to a series of maps apparently not yet in the book trade." He reproduces this in his book which seems to make its first publication date from 1929. There is no text, nor any explanation of the method by which these isohyetals were drawn, and they bring out impressionistically, that is more than actual measures justify, the effect of relief. However, Walter Knoche has now (1929) published three rainfall maps of Chile in the *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*. They are on the scale 1:5,000,000 and show annual, January, and July rainfalls. Knoche refers to earlier maps by Voss, 1907, Jefferson, 1921, and Franze, 1927, making no allusion to a map by Edwards and himself of date 1920, nor does the present map resemble the one attributed to Edwards and himself by Berninger in any but the most general way.

Knoche had at his disposition 310 recording stations up to the end of 1926, compared with Voss's 21, Jefferson's 167, and Franze's 237. He uses about 90 per cent of these as of at least one year of record. He notes complete rainlessness about Arica, "nothing at all like it in the world." On the summits of the Andes from 42° to 48° S. he shows several strips of precipitation greater than 6000 millimeters. The

outer islands south of the Taitao peninsula have three to four meters with less than three to the eastward, in the rain shadow. So does the island of Chiloe, but the mountain ridge near the coast just south of Concepción, called Nahuelbuta, has but 1500 millimeters. The drier country in the central valley just east of Nahuelbuta has an island of drought rather than a south-projecting tongue. This is a general feature of Knoche's maps. When we have a really adequate number of gauge stations in Chile, as Knoche justly remarks, we shall find such islands greatly multiplied in number.

The summer (January) map shows complete rainlessness as far south as Coquimbo. This continues inland as far south as 34°. Not till we draw near Valdivia do we find an end of the dry country (50 millimeters).

In winter (July) there are 50 millimeters of rain from the Andes opposite Coquimbo to the coast a little north of Valparaiso, increasing thence southward to 200 millimeters at Concepción and 300 at Valdivia. There are 400 on Nahuelbuta, and 500 on the Andes opposite. The glaciers of the high Andes in the middle forties are credited with 700 millimeters in this month. No stations are marked on the map, nor is there any list with coördinates of stations or values of rain caught; but further material is promised in a later paper.

MARK JEFFERSON

UNDERGROUND WATERS

WERNER WILHELM KOEHNE. **Grundwasserkunde.** 291 pp.; maps, diagrs., ills., bibliogr., glossary, index. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Nägele), Stuttgart, 1928. M. 18. 9½ x 6½ inches.

This is a general or semi-popular presentation of the available information concerning underground waters, given in compendious form. On the engineering side some of the most important formulas are explained, but in a book of this size it is hardly possible to go into the applications extensively. The agricultural aspects are alluded to and discussed in chapters that are often omitted from books on underground waters. It is a textbook primarily for European students. The problems that the arid regions of America have brought to the front and the interesting and important work of the United States Geological Survey under Meinzer and others are hardly alluded to. The methods of Meinzer probably seem quite special to a European engineer, but in America they lie at the heart of the most important problems concerning underground waters. The book is a useful addition to the existing texts on this important subject.

CHARLES S. SLICHTER

A GEOGRAPHICAL DICTIONARY

OSKAR KENDE. **Geographisches Wörterbuch: Allgemeine Erdkunde.** 2nd edit. vi and 238 pp.; maps, diagrs. (Teubners kleine Fachwörterbücher, Vol. 8.) B. G. Teubner, Leipzig and Berlin, 1928. M. 6. 7 x 5 inches.

The American, other than a professional geographer, who scans this little dictionary might be surprised that *Mudlumps* and *Monadnocks* are technical terms in German. The former refers to the so-called "gas volcanoes" found in the Mississippi delta, the latter to worn-down mountains rising above a peneplain. Professor W. M. Davis introduced *Monadnocks* into the German language, along with *Peneplains* and the adjectives *insequent*, *konsequent*, *subsequent*, *obsequent*, and *resequent* as applied to streams and their valleys. The words sponsored by Davis, however, do not hold the field unchallenged. *Monadnocks* contend with *Härtlinge;* instead of *konsequente Flüsse*, Penck champions *Folgeflüsse*, Hettner favors *gleichsinnige Flüsse*, Passarge would say *primäre Böschungsflüsse;* and the other words have their corresponding

rivals of more truly Teutonic flavor. German physiographic terminology is still in the making.

The number of words in German geographic usage beginning with *Is-* or *Iso-* (from the Greek ἴσος, "equal") is impressive. This, of course, is to be expected. As a way of showing the distribution of certain phenomena it is a common practice in geographical exposition to draw on maps lines through all points having equal arithmetic values with reference to a fixed base. Max Eckert, who discusses more than fifty different types, suggests *Isarithmen* as a generic term for all such lines (*Die Kartenwissenschaft*, Berlin and Leipzig, Vol. 1, p. 11, 1921). Kende does not include this or an equivalent. *Isopleth*, the use of which has been advocated among American geographers by Professor Wellington Jones, he defines in the somewhat specialized sense as "lines connecting points having an equal quantity of heat (*Wärmemenge*) (e. g., at different depths of a lake)." Explanations, however, are given of no less than 26 different isarithmic or, in the broader connotation of the term, isoplethic lines. Some of these are familiar, such as *Isothermen*, *Isobaren*, *Isohypsen*, but others seem novel and ingenious. *Isochimenen*, for example, are lines connecting points having the same winter temperature; *Isokatabasen* and *Isoanabasen*, lines connecting points that have undergone the same amount of crustal depression and elevation, respectively. Perhaps the most curious of all is *Isochronanomalen*, by which is meant lines connecting points that may be reached from a fixed starting point in either more or less time than would be the case if they could be reached at a given mean rate of travel calculated for the whole area mapped.

Kende's dictionary should be helpful to every American student who has occasion to read German geographical publications. It is particularly useful in the fields of physiography and mathematical geography. Many words are included that do not appear in the general dictionaries. For other words the definitions are more satisfactory from the geographer's point of view than the broader definitions of the lexicographer who has to cover the whole language. Furthermore, references are given to publications where the concepts expressed by the various technical terms are explained more fully. Unlike Ewald Banse in his *Lexicon der Geographie* (2 vols., Brunswick and Hamburg, 1923), Kende excludes accounts of regions and places. Brief biographical and bibliographical notes, however, are given regarding individuals who have contributed notably to the progress of geography.